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ERAS, LENSES, SHUTTERS, ETC.

COMPETITIVE PAPERS, VOL. I.

COMPETITIVE PAPERS

ON PHOTOGRAPHY.

VOL. I.

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PREFACE.

THE articles upon photography which appear in this volume have been contributed to the "Monthly Competitions" of the *Amateur Photographer*, and have been awarded first, second, and third prizes at the hands of the examiners. They all contain practical and valuable information and instruction. It is hoped that in the cheap and handy form in which they are now presented to the public they will prove of service, and, in assisting many workers in photography, will advance the science and tend to emulate others to put into the form of essays their experiences in the many and various branches of photography in which they may be interested.

CHARLES W. HASTINGS,
Editor *Amateur Photographer.*

March 1890.

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COMPETITIVE PAPERS ON PHOTOGRAPHY.

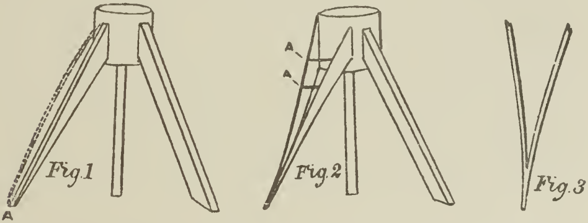
COMPETITIVE PAPER No. I.

CAMERAS.

First Prize—W. V. CORBET

THE following remarks must of necessity be short, and one feels loth to hastily scan any one of the subjects when so much can be said of either. I have dwelt longest upon tripods and cameras, for they are absolutely necessary ; some of the subjects are more in the shape of a luxury, and these I have passed rapidly by.

Place a book upon a table at an angle of, say, 70 degs., prevent it from falling by propping it up with a lead pencil, and you have a rough illustration of one of the principles of a tripod. Widely speaking, any one leg of a tripod supports the other two. The dimensions of leg A, fig. 1, are 5 ft. long by $\frac{3}{4}$ in. thick, tapering from a width of 2 ins. to $\frac{3}{4}$ in. Upon the head B place a sufficiently heavy weight, and leg A will bend, as shown



by dotted line ; now cut the leg down its centre, making two pieces 5 ft. long and $\frac{3}{8}$ in. thick ; erect these two, making one leg, as shown at fig. 2, adding two small cross-pieces AA, and again place the same weight on the head, and the leg will be, comparatively speaking, firm. From this we see some of the principles brought to bear when constructing a leg of the proper shape, shown in fig. 3, which is one of the strongest and best forms. In folding legs this shape should still be adhered to.

A good tripod must have stability combined with portability and lightness, the former in no one detail sacrificed to the latter two. The legs should slide with the smoothness of good workmanship, and when clamped at any height be quite firm. The head should be large, and preferably round in shape, with a piece of short-pile velvet glued over the whole surface of top, the legs to be detachable without having to entirely unscrew fly nut (if used); then camera and head can be packed away together, as the legs strapped in a bundle without their top make a strong and handy parcel, lessening chance of losing tripod screw, and offering a means by which camera, etc., can be swung over shoulder and easily carried. The stand receives a deal of knocking about, consequently its strength should be sufficient to stand the wear and tear of a tour without a case: for what is worse than having a delicate tripod, which, when it receives a small blow or fall, makes the owner quite nervous lest he should pick it up broken? Then I say, have a solid-made one, likely to resist rough work. English ash is undoubtedly the best wood for it to be made of, but it is rather heavy in proportion to mahogany—which wood, if of straight grain and wiry fibre, makes a very serviceable stand; it is light, and for its weight tough, good-looking, but unable to withstand the effects of time, like ash. On the whole, Honduras mahogany lends itself satisfactorily to all purposes required for tripods under whole-plate size. It must not be too low, or stooping while focussing will make the back ache, and the resulting picture will show signs of hurried arrangement and imperfect focussing; at the same time, it must be remembered that extra height means extra strength, and consequently more weight and greater chance of vibration. A plain screw and a flat camera bottom offer a ready means of revolving instrument, at the same time abolishing horizontal front, and lessening weight and complication. It will now be seen that revolving heads and horizontal fronts are not wanted. Ball-and-socket joints are a luxury, certainly not a necessity: nearly all positions given by them can be otherwise obtained; they make the matter of camera levelling very easy, but are an addition to complication and weight without any proportionate compensating gain. Of course they *do* come in very useful in exceptional cases, as the camera can be tilted to an angle of about 45 degs., but for my part I would rather tramp without them. A final word about tripod legs: viz., they should be wide at the top.

We come now to the all-important camera, and I will first pay a flying visit to the different sizes.

QUARTER-PLATE.—If much walking is to be done, a quarter-plate will be quite enough to carry with any comfort (a 5 in. by

4 in. at the most); it can be used in the hand without tripod, and a $4\frac{1}{4}$ in. by $3\frac{1}{4}$ in. plate is a handy size for making transparencies or enlargements, either on glass or paper.

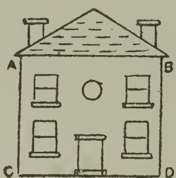
HALF-PLATE.—The popular size, and a very useful one too. The first cost and maintenance are within most people's means; the finished print is about 6 ins. by $4\frac{1}{4}$ ins., which is big enough to be mounted in album without enlarging; the tripod camera and three double-backs need not weigh more than 9 lbs., and, with the addition of lenses and plates, will be quite enough to carry; light purses need not be drained in buying the constant necessary wants, to say nothing of the unnecessary ones; stereoscopic pictures can be taken on a half-plate, and it allows a little margin when exposing for cabinet portraits. To amateurs buying only one camera, let that one be of the half-plate size.

THREE-QUARTER PLATE.—The limit as regards weight, if users wish to be independent of porters, guides, and other kindred but necessary nuisances. The finished print measures about 7 ins. by $4\frac{5}{8}$ ins. (perhaps a little too narrow for length); three-quarter size can be worked with half-plates, which reduces weight and expense, giving the opportunity to use plates one size larger when required; or a better proportioned size, 7 ins. by 5 ins., can be worked.

WHOLE-PLATE, AND 10 IN. BY 8 IN.—Two good sizes. The latter is one for a large pocket and a nature unopposed to carrying a heavy load, or to the company of porters, etc. It gives full scope to an artistic mind, and a clever photographer can make pictures upon a 10 in. by 8 in. plate, when $6\frac{1}{2}$ ins. by $4\frac{3}{4}$ ins. would fail to do justice to the same subject. Anything over 10 ins. by 8 ins. is of limited use, and far beyond the means and sphere of the ordinary amateur. The difficulties of manipulation increase with the size of plate.

The principles and movements of Watson's Premier camera, "heavy pattern," are very good. It is really a working tool, simple, and with bellows of the best form. Erect this camera upon tripod in front of door of house, of shape fig. 4; tilt the front of base-board higher than back, and the left-hand side lower than the right; focus sharp, and the image on screen will be narrower from A to B than the building really is, and likewise apparently falling over: to remedy this, all we have to do is to place the base-board perfectly level, and to enable us to know when it is exactly horizontal all ways, we have recourse to either a spirit-level or plumb-line. I advocate a plumb-line or wire, the former made as follows: from a screw driven into the top of fall-back side, suspend a small weight by a piece of silk, running through a brass eye fixed close to the bottom of fall-back side; or a piece of wire about 4 ins. long properly hung through a screw eye makes an even better plumb than that made of silk. If either of these simple contrivances is broken, it can be repaired almost under any circumstances or in any place, which cannot be said of levels. If levels are used, the best form is undoubtedly the round one made to screw upon fall-back top by Messrs. Taylor; a cap similar to that used on lens hood should fit rather tightly over it for its protection; this form may leak if subjected to great changes of temperature, "although mine never did," and I think this objection is principally theoretical. It is fragile, and, owing to the prominent place it must occupy, forms a tender spot on camera, and if the tripod is the proper height the owner will have to stand on his toes to see what the air bubble indicates.

Returning then to our opened camera, we see the plumb shows it to be anything but level, so having levelled base-board, again look at image, and we find the before-mentioned distortion gone. Now place camera opposite the corner AC, focus sharp on AC



(open aperture R.R. lens) with fall-back out to its farthest, and level, then push in left side of fall-back till BD is quite sharp, and BD will be narrower than correct perspective would render it; again put camera in front of door E at such a distance from it that neither the doorstep nor ridge of roof are on the focussing screen, level fall-back, and by raising front we bring ridge into sight, and by lowering front the doorstep is brought into view. Now place the camera nearer building, at such a distance from it that, raise front as much as we can, we fail to see the ridge upon the ground-glass. If we cannot get upon higher ground, our only resource is to tilt camera upwards till we get in all the view, and by the aid of the plumb we level fall-back, and as a consequence we have an image practically free from distortion, definition at its worst, and lens working under great difficulties. Supposing the corner AC is wanted more on centre of plate, undo tripod screw until the camera will turn easily upon the head, then twist it from right to left; this last movement is a sound substitute for the horizontal front. Again, if we want the longest side of picture vertical, then all we have to do is to turn the reversing back a quarter round. This points to the fact that all instruments should be built square; it adds a trifle to weight and resistance to wind, but enables operator to focus with comfort, and change from horizontal to vertical quickly.

When out with "detective," the new hand often fails to get all the object on plate; to remedy this, finders are of use. A small concave lens, made by Robinson, of Regent Street, and Sharp and Hitchmough, of Liverpool, is easily used, and answers the purpose very well, but it is in the way. Where a finder does come in useful is when using hand apparatus in a crowded place; one can get a picture without making any very attractive movement. But if the owner of a "detective" has a straight and adaptable eye, he has the best finder known. Learn to feel almost instinctively that the object aimed at is on the plate centre; this is the outcome of *practice* only, and when obtained is of great value. It requires some practice to use a finder quickly. When the maximum of sharpness is required, focussing glasses are used, but with them you have to hunt the image over the screen when you want to see the edge as well as the middle. For my own part I prefer a focussing cloth, as I use it for a cover to camera, and a sheath for slides when exposing; the majority of double-backs now in the market want some cover, or good results will never be obtained. A useful substitute for cloth, and one I can recommend from experience, is a kind of pyramidal-shaped bellows, the broad end covering ground-glass and the narrow end open.

We now come to the matter of an Ideal Camera. I have not in any particular gone into impossibilities, and in the limited space at my disposal I cannot even find room to explain the advantages of the instrument described below.

The Camera.

It should have all movements previously described or advocated. They should be easy to reach, and, above all, simple in construction; to be usable as a detective, or in the ordinary way, at the shortest notice; to fold so as to protect weak parts, and have no projections when used as hand camera or when closed; by opening one small door access to be obtained to the means by which all movements are controlled, with power to bring any one of four lenses into operation, and having long extension bellows, and built square; to be worked with roll-holder, "for lightness" (and in the course of time a perfect and rapid film will have been invented). A reservoir of plates come next to roll-holders, and double-slides last; in fact, to use above instrument properly, double-backs are useless. In imagination let us start across country with above apparatus, slipping end of tripod through the leather handle of camera, which will partake of the despatch-box form, and contain roll-holder and two lenses; total weight, $9\frac{1}{2}$ lbs. at most. We start our tramp: coming suddenly upon an excellent subject for detective style, we whip our tripod out of handle, make exposure, and then off we go. Arriving at an object requiring use of stand, we open legs, screw on camera, focus, arrange in the orthodox style, give one or two seconds, as required, shut up legs, and start again; and by the time the light goes, $9\frac{1}{2}$ lbs. will seem to have wonderfully increased, and we shall be saying to ourselves, Next time quarter-plate size will be large enough. It must be understood that no cloth is required for this camera, or packing box.

Criticisms upon Tripods.

(1) Four-fold stands. As a rule they are made too light. Watson's Cyclist's is an excellent form. All joints, centres clips and stays are placed correctly from a mechanical point, the top of the leg is broad. If this stand was made a little stouter, and the bottom joints to slide, it would be one of the firmest and best four-fold stands in the market. Very portable and quickly erected.

(2) A stand of French origin, sold by Abrahams, of Aldersgate Street. It packs into three. Two parts of leg fold, the third and bottom joint slides. The shape and place of joints are good, the leg top too narrow, but, weight for weight, few stands at the price can beat it. It is both portable and light, minimum weight (three-quarter-plate size) $3\frac{1}{4}$ lbs., easy of erection, and requiring little time to put up.

(3) A well-known pattern, No. 27 in Shew's list for 1888. One-half of leg telescopes into the other half. It offers great adjustment, but, owing to length of wood without stay, requires to be made a trifle heavier than a three-fold stand of like firmness. This stand, with the addition of side stays, composes Ashford's patent tripod, which, for a light two-fold tripod, is second to none; it is stayed in every direction, possessing a very broad top, which, if covered with velvet, would be greatly improved.

(4) Metal telescope tripods are made upon the well-known tubular system, and if of good make, are excellent stands, rather heavy, but very adjustable and portable.

A Word as to Keeping Apparatus in Best Working Form.

See that all interior parts of camera, lens and double-backs are dead-black. Blacklead put upon all grooves and tongues of sliding parts of camera and slides, make same work smoothly. All wooden apparatus should be kept in a dry and warm place. The camera often examined for stray light, as follows: Open screen, cap lens, cover head with focussing cloth so as to exclude all outside light, then get a friend to hold a strong light near all parts and joints where light would be likely to get in; if any does find its way through, it will be easily seen, and, of course, must be stopped; then put double-back in camera, draw shutter, take out front, and look as before. If the slides are of book form, close shutter, half open slide, and try the leather hinge. If solid form, put plate in and expose to the sunlight, then develop. Three pieces of rubber for tripod feet are handy on board ship and polished floors. The lens cap should be tied to camera, and tripod screw to tripod head. Two straps nailed to one of stand legs prevent them being mislaid. Too much stress cannot be laid upon the fact that the simpler the apparatus the better. Complex brasswork may be masterpieces of manufacture and ingenuity, but sadly delicate and liable to injury, and consequently become unworkable just when most required, or at the time when repair is impossible. The mania for a camera that would puzzle the old photographer, if he came from his grave, to say what it is meant for, and for one that will double up as thin as a piece of cardboard, and a tripod that will go into the waistcoat pocket, shows itself too frequently in doubled outlined and fogged negatives.

CAMERAS.

Second Prize—JOHN POWELL.

"HAPPY is the man that getteth understanding" is one of the many proverbs handed down from "ye olden tymes" of that wise man Solomon.

But the reader asks, "What did Solomon know about the troubles, not to say 'vanity and vexation of spirit,' of the average amateur photographer?"

Nothing, simply nothing; and yet Solomon might have been classed among the prophets; for, although the amateur may possess the double qualification of artist and chemist, but has not a good "understanding"—I mean a good reliable tripod—his views will be haphazard, and sooner or later he will come to grief.

Did you ever observe an aged man with his feet nervously extended, and feebly clutching with both hands his staff for support, in the vain endeavour to catch a momentary glimpse of some venerated spot, full, perhaps, of affectionate reminiscences—the apple of his eye? Perhaps not; yet, by analogy, you can fairly imitate the picture when, under the gentle influence of the breeze, the feeble knee-joints of your tripod beat time to the rude puffy music, or the tripod-head and seat of the camera, whether from improper balance of the lens or backs, fickle fastenings, or uncertain warpings, or even a slight touch, the camera joins the tripod in "an unholy alliance" to tease your patience, or to damp your ardour, or indeed, to crush out the remaining spark of enthusiasm you possess.

The salient points of the above picture are worthy of our earnest consideration. Matthew Arnold, in one of his addresses to students, laid great emphasis on *lucidity*. Similarly, the word we want stamped on our apparatus is *rigidity*, for without it "our views" will be comparatively worthless. It is better to bury a bad set of apparatus than go weeping all our days. Here, however, a question arises: What is a bad set? Perhaps we shall do best by setting forth the true requirements by examining each part analytically from a scientific point of view, rather than by some invidious selection of a common aunt-sally.

The name of the various tripods in the market are legion.

Ingenuity in these days is by no means lacking, and yet there are few models of portable tripods that could be justly stamped with the word *rigidity.*

Portability is the great, and to some extent the just, demand of the ever-wandering photographer. We rightly welcome it where excellence is not required to play second fiddle; but, when *rigidity* is sacrificed, it becomes fiddle-de-de, merely a plaything or worse.

It is manifest that when pressing the tripod firmly home, the legs are either under a compressive strain, a cross strain, or a combination of both. Let us carefully consider what are true requirements in these cases.

Under a compressive strain it is scarcely possible that the fibres of even the softest pine could be crushed with the heaviest of cameras. However, there is the attendant evil of *buckling.* Let us assume that the legs are 48 ins. long, that the least dimension is 1 in., and that the joints are rigid. Here we have a ratio of 48 to 1. If the thickness was $\frac{3}{4}$ in., we have a ratio of 64 to 1, whereas if the ratio exceeds 40 to 1 and the line throughout is not perfectly maintained, buckling is inevitable. It increases or decreases according to the movements of the operator, causing an irritating vacillation and allowing full play to the least puff of wind.

When the legs are subjected to a cross strain it is more than probable that, with average elasticity of timber, the joints are the weakest parts. Considering the leg as a beam supported at both ends, it is evident that the weakest position of jointing is central; in fact, whether we consider the joint or the leg as a whole, this is true, so that in triple folding legs the centre pieces should be proportionately stronger than either the upper pair or the lower part. The latter is usually done, but the former has had little attention.

There is one important factor which seems to have been entirely overlooked, viz., that with the same cubical dimensions—in other words, the same weight of timber—we can obtain greater rigidity. Viewing the ends of most tripods, we note that the pieces are approximately square, that the breadth and depth are nearly similar, instead of being *long rectangles.* Let us take two examples; one of the former and one of the latter, and consider their respective comparative strengths:—

	Breadth.		Depth.		Content.
No. 1. Approximately square section, in eighths of an inch =	5	×	6	=	30
No. 2. Long rectangular section, do. =	3	×	10	=	30

In the first case, the breadth is assumed as $\frac{5}{8}$ in., and in the second case as $\frac{3}{8}$ in. Now, under a cross-strain the strength is proportional to the breadth, so that No. 1 : No. 2 :: 5 : 3, that is, No. 2 is only $\frac{3}{5}$ of the strength of No. 1. Next, in the first case we have taken $\frac{6}{8}$ as the depth, and in the second case $\frac{10}{8}$. Now the depth is most important. The strength varies as the square of the depth, so that in this respect No. 1 : No. 2 :: 36 : 100, or in other words, No. 2 is nearly three times as strong. Lastly, combining the former and latter calculations, it will be found that No. 1 : No. 2 :: 180 : 300, or that No. 2 is nearly double the strength.

Further, as already stated, the ratio of length to depth in No. 1 would be 64 to 1, whereas in No. 2 it would be 38·4 to 1, a considerable advantage.

Again, the clear space between the joints would be, say, 15 ins. Hence the ratio of length to breadth, that is 15 to $\frac{3}{8}$ in., would be 40 to 1. Further, as this only applies to one part, and that part could not buckle under ordinary circumstances without the pair being similarly affected, it is manifest that it is fully equal to the other proportions, the only disadvantage being the formation of a rectangle with the joint-pins, which would be somewhat dependent on a sound well-finished joint. To this, however, both are comparatively dependent for rigidity.

In reference to the several joints under cross-strain, since the square of the depth applies, and the pin or feather support is central, the difference in depth materially affects the strength. In this case a leverage is set up, hence the greater the length of bearing the greater the strength. The wedge joint is very useful, but too often the band is miserably narrow. The security of the wedge depends mainly on the roughness of the surfaces under pressure, while too often these parts, as, also, the wedges, are highly polished.

It is almost unnecessary to add that the ends of the folding tripods should be brass finished, as otherwise the constant opening and closing, or, in other words, the wear and tear, would render the joints very doubtful.

Why have three legs, and not four, been adopted? It is obvious, for rigidity. Three points determine a plane. So, likewise, it is obvious that a camera, the base of which is a plane, should *only* have three points of support. This rule should be beyond a doubt, yet in how many models of tripod-heads is the least attention paid to it? Further, these raised points of support should be sufficiently distant that the centre of gravity of the camera falls well within the triangle, for if not, the security of the camera will depend solely on the screw.

Perhaps at this stage it will not be a digression to remark that the practice of using a folding focussing screen is objectionable when by loading down the tail of the camera, too often the case when working with a light landscape lens, the screw is brought into play. On the other hand, with a heavy portrait lens the probability lies in the opposite direction.

The ball-and-socket joint is a good device if sufficiently large, but it is particularly open to the last objection, while in practice it is too often used as an expedient for altering the level of the camera.

Before leaving this important part of the subject the author may be pardoned for remarking that he has designed a tripod upon the foregoing bases. It folds up, head included, into three thicknesses by a strong hinged arrangement; the head has three raised points of support, and all the joints are specially devised for rigid support.

The advantages of the pyramidal over the old square-bellows camera is decided. The reason which seems to have led to this decision, that it *closes up* into a lesser space, is, however, comparatively of minor importance to the fact that it presents *a smaller area when open.* For when open the least possible wind surface is a desideratum; indeed, from a scientific point of view it should be an axiom. This being so, the greater the reductions of such and similar necessary accessories the better; hence all parts, when the camera *is extended,* should be as snug as possible. Here, again, the folding focussing screen is objectionable. From this point of view, that of wind pressure, the use of a quarter-plate and subsequent enlargements should rule in doubtful weather; it is better to go to a little extra trouble than fall short by spoiling your plates, which is almost a certainty with the slightest, perhaps imperceptible, quiver of your camera.

The bushing in a camera should be directly below its centre of gravity. This with a folding focussing screen is impossible, for if during the operation of focussing the above holds good, the next operation of adding the dark slide without sensibly affecting the conditions is doubtful. If, however, the base or rest be proportionately enlarged so that the centre of gravity of the screen when folded back falls within the base, and the weight of the double slide fairly balances the camera in respect to the base, the evil is minimised. It is always well to remember that to some extent the condition of unstable equilibrium holds good in respect to the camera.

View-finders are mainly of advantage for instantaneous work. Their truth is based on the absolute parallelism of their view with that of the lens, so that, at best, they are only approximations, and are, moreover, objectionable from the point of wind pressure.

The rising and lateral movements of the front, as, also, the level and swing-back, are useful adjuncts in difficult positions, as strict parallelism of view with the back in a normal position are essential elements.

Having now explained my views, together with the salient points of mechanical interest, it only remains to describe an "ideal camera." Here, however, a difficulty presents itself. Few birds come into the world with all their feathers on—so with new-fangled notions. They rarely approach perfection: it is rather the result of maturity.

Suspended from a telescopic focussing bar by combined clamp and link arrangement, is a conical-shaped camera. It is provided with a circular disk, fitted with a light-tight groove, carrying parallel rebated strips for focussing screen or dark slides.

The drawings, details, and perspective sketch will assist to render the above more intelligible, as well as to set forth the minor parts.

It will be noted that the short tubular support (A) is screwed so as to fix the tripod, and is adjustable relative to the centre of gravity of the camera. The braces BB and CC are similarly arranged on the lower focussing bar, the former being secured under the point of suspension, and the latter pair close to the operator, so as to admit both of facility of lateral movement and support as well as fixing the line of view.

The sectional detail shows the method adopted of forming a simple and inexpensive light-tight joint between any two cylindrical rings, the circular section being a rubber velvet-covered ring, or rings, if necessary. An alternative arrangement would be to cover only the interior surface of the metal.

The circular disk may be rotated into any position, so that the vertical or horizontal lines on the screen may be adjusted without either disturbing the tripod, the risk of altering the line of view, or changing the focus.

By the combined arrangements set forth, it may be fairly assumed that the camera possesses all the advantages of the swing-back and rising and lateral movements of the usual model, while, with similar conditions of weight and size, it is a far more reliable and rigid apparatus. Further, it dispenses with the usual reversing back, its centre of gravity is below its support, the whole being firmly braced, while it not only closes up into a small compass, but, far more important, it presents, *when extended,* the least possible equivalent area of pressure.

The advantages, briefly, may be summed up as follows:—

(1) The legs practically meet at a point.

(2) The camera is in stable equilibrium.

(3) It dispenses with the use of a level.

(4) The line of sight is always normal to the plate.

(5) It presents the least equivalent area of pressure to the wind, which, other things being equal, is a decided advantage in form over the pyramidal as the latter is over the square or rectangular form.

CAMERAS.

Third Prize—J. H. TAYLOR.

The Tripod Stand.—The points to be regarded in the selection of a tripod stand are height, rigidity, non-liability to derangement, adjustability, lightness, and portability.

The height should be such that when the legs are spread out the operator may focus erect.

Rigidity is most readily ensured by making each leg of one piece of wood, but though lightness may be thereby secured, yet adjustability and portability are sacrified.

Adjustability, most necessary on uneven ground, is secured by making each leg of two or more sections, of which one, generally the lower one, is formed of a single piece of wood sliding between parallel laths, which form the section above. An arrangement for clamping the legs at the desired extension is requisite. In some stands a collar of sheet-brass, sliding on taper legs by a wedge action, grips the sliding part between the parallel laths. But this arrangement is liable to be put out of order by accidental deformation of the brass collar and other causes, and when (from the weight of the camera or the smoothness induced by wear) force is necessary to tighten the collar, it is apt to be no easy matter for the operator to apply by hand sufficient force to the thin edge of the collar. The sliding legs are best clamped by a screw which takes through a metal collar embracing the parallel laths and slider and compresses them together through the intervention of a metal plate, which distributes the pressure and prevents wear. For convenience, the adjustment of the legs should be made high up, that the effect on the level of the camera may be simultaneously observed. The best arrangement would be at the bottom a solid leg sliding between parallel laths, and here allowing large adjustment, then a solid piece hinged to the parallel laths at their upper end (with an arrangement to lock it in line with thelaths), and itself at its upper end sliding between the lower ends of the spring laths (which engage with the pivots on the triangle), and there controlled by a clamping screw.

The spring laths to engage with the tripod head are essential to rigidity, for if an undivided leg be attached to the tripod, owing to the freedom of rotation on its pivot, necessary for its outward movement, it cannot be made rigid unless either the pivot be made long or projections of the tripod head downwards be provided, against which the legs may be severally clamped.

The tripod form is adopted for the stand because in this there is equal pressure on each leg, and if one more were provided it would be no easy matter to make a fourth take a bearing. The camera, apart from wind pressure, will be in a position of stable equilibrium, provided that its centre of gravity lies vertically above the triangle formed by joining the feet of the legs.

The base screw as generally fitted to cameras is awkward to fix, especially in cold weather, apt to have its threads worn off, and sometimes to snap off. A more secure attachment is a dovetailed piece of metal or hard wood fixed to the base of the camera, which may be slid between V guides (like those of the slide-rest of a lathe), attached to the tripod head.

Reversing Head for the Tripod.—Most pictures are taken on oblong plates with the long side now vertical, now horizontal, and amateurs in the field frequently have occasion at short notice to change from the one position to the other. In cameras of oblong shape, the change is generally effected by unscrewing the camera from the base board and screwing it to a wing, but this is a tedious process. On this account square cameras have come into use for oblong plates, the change being effected by either a rotating back or a reversing back. But square cameras involve greater expense, greater weight, and increased bulk.

These inconveniences may be avoided (*crede experto*) by using an oblong camera with a reversing head, which by a movement of rotation quicker in action than the use of either a reversing back or rotating back, changes an oblong camera from the horizontal to the vertical position of the long side, the camera in each position being well over the tripod head, and which further gives the operator the power of elevating or depressing the camera through any desired angle from the horizontal to the vertical at will, and this with either the long or the short side of the plate horizontal. Moreover the attachment of this reversing head to the triangle by a central pivot enables the camera to be turned round, so that the lens may be directed upon any object as centre of the view.

Levels.—A level is necessary to ensure the verticality of the plate, which is essential, even when rectilinear lenses are used, to the correct rendering of the straight lines of architecture.

Spirit levels, whether linear or circular are less easy to read and less precise in their indications than plumb levels, especially when the latter are of some length. Moreover, plumb levels are available for any position in their plane of motion.

Finders.—A finder is a convenient attachment to any camera, especially one that is adjustable, so as to show what will come into the field when different lenses are used for the same camera, for which a finder with a lens is useless. The simplest finder would be too small sights, like gun-sights, on the middle of the front and back frames of the camera. These, with the judgment which practice soon gives of the size of the image which the same object at different distances will form on the screen, will be found amply sufficient.

Focussing Glasses.—Focussing glasses, which act partly as larger eyes, gathering the light of the image, and partly, when used as I advise, by excluding extraneous light, are often necessary when dark or badly lighted objects are to be photographed. The best form of focussing glass, which should be achromatic is, that which, while held in contact with the focussing screen, on which the image of some clearly defined object has been carefully focussed by eye on a bright day, may be securely clamped in the position in which that image is found to be most clearly defined. The same operator will then, by the aid of this focussing glass, feel confident of getting the best results under circumstances in which there would have been difficulty in focussing by the unaided eye.

The Camera.—The points to be held in view in the construction of a camera are—accuracy of make, rigidity in use, lightness (so far as is consistent with strength), simplicity of construction, portability.

The camera, as generally and very conveniently made, is formed of two frames of wood attached to a base-board, and connected by a bellows body. The front and back frames should be parallel, and more parallel when a swing-back is not used; but, above all, it is necessary that, when the focussing-screen has been set and clamped parallel to the front, and the dark slides then successively substituted for the focussing-screen, a plate in each side of each dark slide should be parallel to the front, and exactly at the same distance as the screen had been.

The base-board, which for portability is generally made to fold, should, when extended, be perfectly rigid. It is sometimes, to give a long range of focus, found convenient to form a base-board of sliding-frames similar to those of an extending table.

The base-board should not in use extend backward beyond the double backs, since then it would be in the way of focussing; nor should it extend beyond the front, since part of the view might be cut off. The base-board, therefore, is best constructed with two sliding-frames, one of which carries the front and another the back, while a third part is attached to the tripod-head. For focussing, racks and pinions are to be preferred to a winch-screw, since the latter is in the way. Two pairs of racks and two pinions are better than one, for one pair can be used to effect an approximate adjustment of the focus, and the other, of course the nearer one, for the fine adjustment. A scale of inches, divided into tenths, or a millimetre scale, on the base-board, will be found useful for making the necessary adjustment for instantaneous pictures. To use this, tabulate on a bright day the points on the scale at which objects at different known distances are in focus, and this for each lens used in the camera. Then, when it is desired to photograph a moving object, *e.g.*, a yacht, all that is necessary is to estimate the distance at which it will cross the field, to refer to the table already prepared, and to adjust the camera by the scale. In all cases a clamp should be provided to fasten the moving frame when the focus has been obtained, and prevent any displacement arising even from the slight force necessary for putting the double-back in place or for withdrawing the slide. The resulting picture will then be sharp if the shutter used be quick enough.

Swing-Backs.—Swing-backs are essential to enable the plate to be placed parallel to the plane of a building when the lens cannot be so placed as to have its principal axis perpendicular to the plane of the front of the building, since this parallelism is essential, even with rectilinear lenses, to the reproduction of straight lines. The more fully the building occupies the plate, and especially with high vertical lines near its extremities, the more essential this parallelism is.

The swing-backs should turn on pivots whose centres are in a line which falls on the surface of the screen (*i.e.* of a sensitive plate in the double-back), since then the part of the object at the centre of the plate can be sharply focussed, and the effect of a slight displacement of the screen, by use of either swing-back, be noted with reference to the axial part of the picture, which will be unaffected; whereas if the swing-back be rotated, as in some constructions, about an axis outside the plate, the least displacement alters every point of the image, and the adjustment of the swing-back to the best position becomes purely tentative.

The Bellows.—The bellows should be parallel, since conical bellows, with short-focus lenses, or in eccentric positions of the lens on the camera front, are very apt to cut off part of the view. Besides this, conical bellows would prevent the advantageous use of the rotating front in conjunction with the internal shutters.

Internal Shutters.—In taking panoramic views it is often seen that half of the plate longitudinally would be sufficient for the picture; similarly that for a cliff, half the plate vertically would be sufficient. Sometimes a quarter of the plate would suffice for a picture. It will then be a clear gain to provide facilities for taking a picture on half the plate vertically or horizontally, on one quarter or on the whole plate at will.

To effect this, four flap shutters, with axes parallel to the length of the plate, are pivoted close to the opening in the back frame of the camera and immediately in front of the focussing screen, so that each when in position covers one-fourth of the plate, and when open lies against the upper or the lower part of the bellows, as the case may be. The edges of these shutters close against one another so as to prevent the passage of light. The mode of effecting this I omit *spatiis exclusus iniquis.*

By the use of the slides on the rotating front of the camera in conjunction with these flap shutters it is possible to bring the lens over the centre of that part of the plate which it is intended to expose, and the determination whether part or all shall be used, and the necessary arrangements of the flap shutters and of the lens can be made even when a double back is in place and the slide drawn.

This arrangement, with a short-focus lens which would cover a quarter-plate or 5 by 4 plate, forms a very useful camera for small instantaneous views.

If a shallow box camera with two fixed divisions at right angles,

be provided for quarter-plate double slides, and the lens of a secret camera be removed and screwed on to a plate rotating about the centre of the front of the camera, so that it may be brought successively over the centre of each quarter of the plate, and a light shutter provided, it will be found much cheaper to use quarter-plates than the circular plates of the secret camera, and there will be the further great advantage that it will be possible to cut up the plates before development.

Pictures taken by hand-cameras are frequently blurred by involuntary movement of the operator, for movement here is far more prejudicial than in the object. Hence it is desirable to use a light stand whenever secrecy is not the object.

Stereoscopic Cameras.—If in a camera with a partition two lenses be used simultaneously to take stereoscopic pictures, the resulting prints must be cut and transposed. This form is well suited for taking moving objects, but not for printing transparencies. If in a camera of the above construction one lens moved from side to side takes the two pictures consecutively, the same inconvenience is found. If, however, as in Powell's monocular stereoscopic camera, one lens is used, and in the right-hand position of the camera the left-hand side of the plate be exposed, and *vice versa,* the negative will yield transparencies and paper prints which need not be cut and must not be transposed.

The space at my disposal does not allow me to describe how to build a camera of large dimensions. I have, however, seen part of my plan described in the account of an American patent, 322,003, page 732, *Photographic News*, Nov. 16th, 1888.

COMPETITIVE PAPER No. II.

LENSES.

First Prize—Rev. T. Perkins.

In this paper I shall endeavour to treat the subject of photographic lenses with as great an absence of technical terms as possible, and I shall give explanations of such as are used when it appears needful, but as space is limited, I shall assume that the reader is familiar with the terms in common use, and is also acquainted with the fundamental laws of reflection and refraction, and the manner in which an image is formed by a double convex lens.

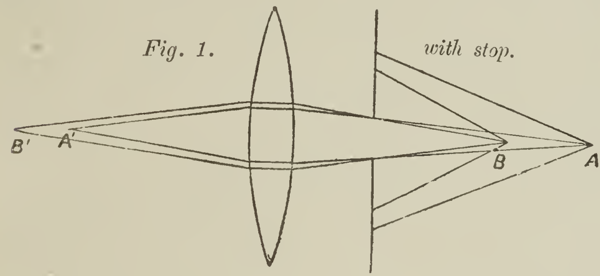
I shall begin by speaking of some of the defects of lenses, and the manner in which they may be cured or lessened. If we use a double convex lens we shall find that rays proceeding from a point on the axis, and refracted by the margin of the lens, are brought to a focus nearer to the lens than those which pass through the central portion of it. This defect is called "spherical aberration." It can be cured for rays proceeding from points along the axis by associating with the convergent lens a divergent one, which will spread out the rays passing near the margin to a greater extent than those which pass through the central portion of the lens. But when the lens has been thus corrected for spherical aberration for rays proceeding from points along the axis, spherical aberration will still remain for other rays. This defect can be mitigated by the use of stops, the action of which will be explained further on.

We will next consider rays proceeding from two points at different distances from the lens, but both situated on the axis. It will be found that rays proceeding from the nearer point will be brought to a focus at a greater distance behind the lens than those proceeding from the other. Hence it is impossible to get sharp images of these two points at the same time; no arrangement of curves or combination of glasses can do this. "Depth of focus," as it is called (though the term is an incorrecton for no lens possesses any real depth of focus) can be only obtained by stops, the action of which I will now explain.

Suppose A and B to be two points on the axis of the lens, and that rays from them are brought to focus at A′ and B′ respectively.

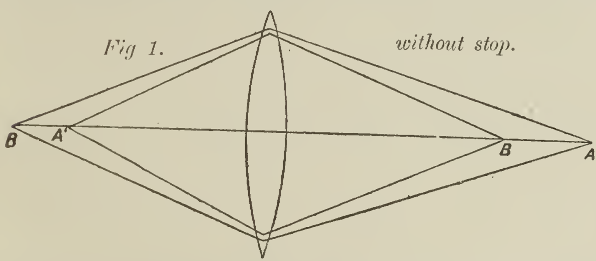
If we place our ground-glass screen at A', it is evident that rays from B will not be represented by a point but by a small circle but if we place a stop in front of the lens it will cut off the outer rays proceeding from B, and therefore the outer rays of the cone of light issuing from the lens, hence reducing the size of the small circle. By using a sufficiently small stop this circle will be apparently a point, and the image of B will be practically in focus at A'.

Fig. 1. *with stop.*



It will be seen that, using the same lens, to halve the diameter of the circle of confusion, we must halve the diameter of the stop, thereby reducing the light to a fourth of its former intensity. Again, if we compare two lenses—one, say, of 4, one of 8 in. focus —and if we suppose our diagram to represent to scale the 4 in.

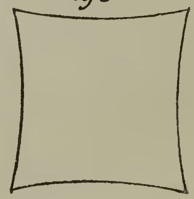
Fig 1. *without stop.*



lens, then to represent the 8 in. lens every line must be made twice as long, consequently the diameter of the circle of confusion will be twice as great, hence to reduce this with the 8 in. lens to the same size as with the 4 in. lens, we must use a stop of *absolutely* the same size on each, or in other words we must use a stop on the 8 in. lens of only one-half the relative diameter to the focal length of the lens. From this we see that the shorter the focal length of the lens the larger relatively the stop may be to secure the same sharpness. By giving greater "depth of focus" a stop modifies another defect, viz., curvature of field. In a simple lens it is found that rays proceeding from points not on the axis are brought to a focus nearer to the lens than those proceeding from points on the axis; in other words, the sharp images of points situated on a plane perpendicular to the axis will be situated on a spherical surface concave towards the lens. If the stop be such that it will allow the screen to be moved a small distance without practical loss of sharpness, we can by focussing a point midway between the centre of the field and its edge, get the whole picture practically in focus although the field is slightly curved. The optician, however, can flatten the field by proper choice of curves and combinations of glasses, though he cannot give depth of focus, all lenses of the same focal length, if the same stop is used, having the same depth of focus, notwithstanding all the claims made that this or that lens is remarkable for depth of focus. To test for flatness of field, we may proceed thus: focus an object some distance off, say 50 to 100 yards, placing the camera so that it occupies the centre of the field; then turn the camera so that it occupies one side of the field, and re-focus; then note how much the screen has had to be shifted; of two lenses of the same focus, the same stop being used, that has the flattest field with which least shifting of the screen is required. It may be that no amount of focussing will render

Fig 2.

Fig 3



the object sharp, when it is not central in the field; the want in sharpness is then due to spherical aberration, and can be reduced by using a smaller stop.

But while stops cure or modify these defects, they give rise to another, namely, distortion. If a stop is placed in front of the lens, rays from different points in the object fall on different parts of the lens, each slightly larger than the stop, hence the resulting picture is formed by different parts of the lens differing from one another in thickness and the inclinations of their surfaces, hence different points are differently displaced, the result being that the picture of a square, whose centre is on the axis and whose plane is perpendicular to the axis, has the form shown in fig 2. If the stop had been placed behind the lens, the form would have been that shown in fig. 3. By placing a lens before the stop and a similar lens behind it, a doublet is formed, free from distortion, since the defects caused by the two lenses neutralise one another. Such lenses are called symmetrical or rectilinear. With single lenses the distortion is greater the greater the distance between the lens and the stop.

Chromatic aberration, or non-coincidence of the chemical and visual foci, is caused by the different degree of refrangibility of the differently coloured rays of which light is composed; fortunately, however, by making the lenses used for destroying spherical aberration of different kinds of glass which, for the same amount of bending of the ray, draw out the spectrum to unequal lengths, it is possible to combine some of the differently coloured rays so that they may be brought to a focus at the same point. The image which we see on the focussing screen is chiefly formed by the yellow rays, while the rays which chiefly affect the sensitive film are the blue, violet, and ultra-violet ones. If, when we have carefully focussed a view on the ground-glass we find that the negative is not as sharp as the view appeared on the screen, we should first see if this defect is due to the dark-slide being "out of register," which we can do by putting a sheet of ground-glass in the dark-slide in the place of the plate and focussing on this, having previously drawn both shutters out. If we find the defect is not due to this cause, we may suspect that the chemical and visual foci do not coincide. Let us paste a sheet of printed matter on a board and place this in a position slightly inclined to the vertical, and photograph it; then let us note which line is the sharpest and how much the screen must be shifted in order to bring this line to a focus on the screen; afterwards, when using the lens, we must move the screen through this distance before exposing a plate.

It is often useful to find the exact focal length of a lens. This is most easily managed thus: Choose a view in which there are two distant objects, at some distance from each other, standing out against the sky line. Focus these, and note the exact points of the screen which their images occupy; now remove the glasses from the mount, use the smallest stop to get a "pin-hole" image on the screen, shift the screen until the two objects occupy the same places as before, now measure the distance between the screen and the stop; this is the equivalent focal length of the lens. It is advisable to measure the diameter of the stops, as they sometimes differ considerably from what they are stated to be, sometimes from carelessness of the maker, sometimes, no doubt, from the fact that they are made to gauge, while the lens, excellent in other respects, may not have exactly the focal length intended, for there is great difficulty in grinding two lenses to exactly the same thickness, and difference of thickness will affect the focal length. I have found similar lenses by the same maker differing in focal length by more than half an inch from each other and from that stated in their catalogues. Single lenses are frequently troubled by "flare-spot"; this is due to the stop being incorrectly placed. Sometimes unscrewing the lens a turn or two in the mount may cure the defect. Flare-spot is caused by the image of the stop formed by reflection at the inner concave surface at the back of the lens, again reflected by the front surface being brought to a focus on or near the sensitive plate. The brightness of the image does not depend on the size of the stop, while the brightness of the picture on the ground-glass does; hence the smaller the stop, the greater the contrast, and a lens which does not show signs of flare with a large stop will be unusable with a small stop, owing to this defect. If the image is brought to a focus considerably behind the screen, or about midway between the lens and the screen, as in Wray's landscape lenses, or if the rays from the stop, after having been twice reflected internally, diverge, the light is so much diffused and weakened by the time it reaches the sensitive plate that it has no injurious effect. "Ghosts" are troubles we meet with sometimes when using doublets. When there is a very bright object on one side of the picture, rays from it reflected from the front surface of the back combination on to the back surface of the front combination, finding their way to the plate, cause a patch of fog. A lens must not be condemned on this account; if we cannot avoid the bright object we should use a single lens, or a portable symmetrical, which is less troubled by this defect than rapid symmetricals, owing to the greater closeness of the lenses. In one negative, among many scores taken with the same lens, there was a bad ghost, but by rubbing it with a rag dipped in spirit, I completely destroyed the ghost. Vague statements are so frequently made as to the comparative rapidity of various forms of lenses that I have recently made a series of experiments under favourable circumstances for putting this to the test. Three lenses were chosen—a rapid symmetrical 6½ in. focus; a wide-angled rectilinear, 6 in. focus, and a plano-convex single landscape, 6½ in. focus. I made stops accurately *f*/32, and exposed plates within a few seconds of each other on the same view in dull weather, which allowed a long exposure, which could be accurately timed. These plates I developed side by side in the same dish; in all cases those exposed with the rapid symmetrical and the single landscape came up simultaneously a little in advance of the plate exposed with the wide-angled rectilinear. It would appear that what the single lens gained by having fewer reflecting surfaces was counterbalanced by the squeezing together of the rays which had passed through the front lens of the rapid symmetricals, so that more rays got through the stop, whereas the greater nearness of the lenses in the wide-angled rectilinear deprived it of this advantage. In brilliancy and clearness of shadows there was little to choose between the single landscape and the wide-angled rectilinear, both of which beat the rapid symmetrical in this respect.

I then made experiments with a view to testing definition with similar stops, using these lenses, and a fourth, a single meniscus landscape. The results may be thus summed up: With the larger stop, *f*/11, the plano-convex and the rapid symmetrical gave equally sharp definition in the centre, but the area of good definition was rather larger with the rapid symmetrical. As smaller stops were used the results became practically identical; with the meniscus no real sharpness could be obtained on any part of the field with a stop larger than *f*/16. With this stop and *f*/23 the definition was more equal all over the field than with the other two. The wide-angled rectilinear had its largest stop *f*/16; with this the centre was sharp, but, owing to curvature of field, the edges of the plate were out of focus; but with *f*/23 a half-plate was well covered, and with smaller stops a whole-plate. I have also tried a Voigtländer's rapid Euryscope, focus 8¾ ins. With *f*/6 a quarter-plate was covered, but no sharpness could be obtained with this stop by any focussing beyond about 2½ ins. from the centre of the field, owing to spherical aberration of oblique rays; by using smaller stops the area of sharpness was extended, but not to the same extent as with a rapid rectilinear. I am therefore led to the following conclusions: For pure landscape, or for subjects in which buildings do not occupy the greater part of the largest plate the lens will cover, use a single landscape, on account of its greater brilliancy. With the plano-convex as made by Wray, distortion is very slight. For buildings, when great rapidity is not required, use a lens of the portable symmetrical type; when a stop of *f*/8 is needed, use a rapid symmetrical or rectilinear, for though some singles are made to work at *f*/8 they do not with this stop give sharpness enough for general subjects. The rapid symmetrical, if stopped down, will form a fair substitute for a single landscape. It will also be useful for portraits, *f*/8 generally giving sufficient speed; but if greater rapidity is desired a rapid Euryscope may be useful. Portrait lenses working at *f*/4 or *f*/3 are not much needed now that plates are made so rapid. In portrait lenses, nearly everything—depth of focus, equality of illumination, flatness of field—is sacrificed to rapidity. When a rapid exposure is required on a view containing objects at various distances, use a short-focussed rapid lens, and enlarge; long-focussed rapid lenses with full aperture, will not give foreground and middle distance even in moderately good focus together.

A few "dodges" sometimes useful may conclude this paper. Half a doublet forms a landscape lens which will work with about *f*/23 or *f*/32; in many of Ross's rapid symmetricals, the two combinations are of different foci, and as either will screw on the back of the lens tube, two different singles may be obtained. A doublet of intermediate focus may be obtained, by removing the back combination and replacing it by the back combination of a doublet of longer focus. Ross's portables may be thus used. It is well to have a cap to fit each end of the lens tube. Dust is thus excluded, and the lens protected from injury. But, despite all care, dust will find its way to the glasses; to remove it, dust with a camel's-hair brush, then wipe with chamois leather or a soft silk handkerchief kept when not in use in a broad-mouthed stoppered bottle. A little pure alcohol may be used to remove stains that the dry leather will not remove. The lenses when not in use should be kept in a case with a division for each, or put away in a box, each lens being placed in a bag of chamois leather.

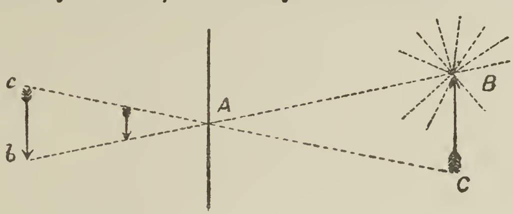
To determine if a lens is correctly centred, place a candle at some little distance before the lens and a little on one side, removing the ground-glass screen, and several images of the candle formed by reflection will be seen as one looks into the back of the camera. Unscrew the lens-mount slowly; if the images just described remain steady, the lenses are well centred; if not, one or more is "out of centre," and the lens should be returned to the maker.

LENSES.

Second Prize—J. H. HARGRAVE.

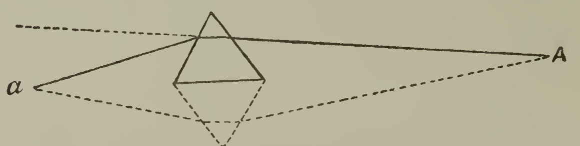
In sending this competitive paper I shall deal with a few of the qualities common to most lenses, and although my remarks are confined to single lenses it must be remembered that those of double and more complex lenses are almost if not quite similar. For a thorough knowledge of the working of a lens it is necessary to understand something of the action of light. Any object capable of being seen is sending off rays of light in every direction, from every point, whether these rays emanate from the object's own illumination or are derived from reflected light.

Suppose we take a piece of tinfoil and make a very small hole (*A*) in it, capable of admitting one ray of light, and place an object (*B C*) in front of it. The point *B* is sending off rays of light in every direction, as shown by the dotted lines. Of these



one, and only one, can pass through *A*, all others being stopped by the tinfoil. This one, however, proceeds until it falls upon a screen placed at *b c*, and forms a little spot of light at *b*. It will be observed that no other ray of light can fall upon the point *b*, and also that if the ray from *B* be bright, dull, or coloured, the illumination at *b* will be bright, dull, or coloured accordingly. Considering that every point in *B C* is sending off similar rays, it will be seen that we get a series of small spots of light on the screen each touching the adjoining ones, and each corresponding in brightness and colour to some spot in *B C*; therefore, this aggregation of small spots forms a picture or image of the whole object. It should be noticed that the image is inverted, and that the screen may be any distance from the hole, the effect of altering the distance being to make the image larger or smaller, and fainter or stronger. Photographs can be, and have often been, taken with such an arrangement, but it is very difficult to make a small enough hole to give good definition, and the exposure requires to be very long. To avoid these defects, and also to enable the image to be seen, for it is very faint, a lens is used.

Taking a glass prism from a chandelier, and looking through it, it will be found that rays of light are bent as shown in full lines, and that a ray from *A*, instead of passing straight on, will pass through *a*.



Suppose another prism be placed underneath the first, as shown in dotted lines, one other, and only one, ray of light from *A* will meet the first at *a*. Now the action of a lens depends on this bending of the rays, which is technically called refraction, and it is ground to such a shape that all rays passing through it from *A* will *very nearly* meet at *a*, which point, if *A* be a very long way off, is called the principal focus, and the distance between *a* and the centre of the lens is called the focal length. It is to be noted that if *A* be nearer the lens, *a* must be further away, as the amount of bending of the ray will be the same. The words "very nearly," written above, have been emphasised, as the rays passing through the outside of a lens meet, not at *a*, but some little distance away from it, thus causing the image to be somewhat imperfect and blurred. This defect is called spherical aberration. It is, indeed, possible to grind a lens so that all rays emanating from *A* will meet at *a*, but other qualities would have to be sacrificed, and makers seek after the best average.

In practice we can lessen the evil effect of spherical aberration by using a stop, which is a piece of metal that cuts off all the outside rays of the cone of light emanating from a point, but admits the centre ones, thus avoiding the disturbing effect of the former, and thereby helping definition.

Stops, however, have another very important action which must be considered. Rays of light proceed from a point, and passing through the lens fall upon a point on the screen. Suppose a certain number of these rays, numerically represented by 100, pass through the stop marked *f*/8, these fall upon the screen and do a certain amount of work (forming the latent image) in a certain period of time. If the stop *f*/16 were used instead, the area of its opening being only $\frac{1}{4}$ that of *f*/8, only 25 rays could pass, and these would naturally take four times as long to do the same amount of work; hence the rule, the exposure varies inversely as the area of the stops, or, in other words, inversely as the squares of their diameters. It will thus be observed that definition and rapidity are opposed to each other—to get one the other must be given up. It would almost seem from the foregoing that exposure depends only upon the area of the stop, the focal length having nothing to do with it, but this is not so, the above only referring to different stops in the same lens. Looking back to the case of the hole in the tin foil, it can be seen that if the screen be twice as far away from the hole the image will also be twice as long; the same holds good with lenses, except that they will only work at one distance, so that if one lens has double the focal length of another it will yield an image also twice as large in lineal dimensions, that is four times as large in area. If an object be focussed with two such lenses, and the stop marked *f*/8 inserted in each—that is, the stop whose diameter is $\frac{1}{8}$ the focal length—we get in the one case an image four times larger than in the other, and also the area of the stop four times larger, the one diameter being double the other. Now suppose rays of light, represented numerically by 100, to pass through the larger lens from the object, and form an

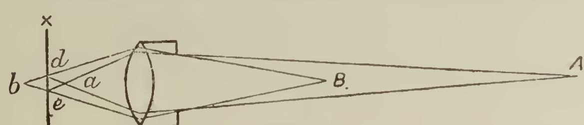


Fig 1

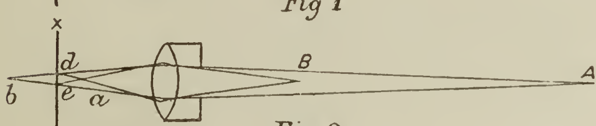
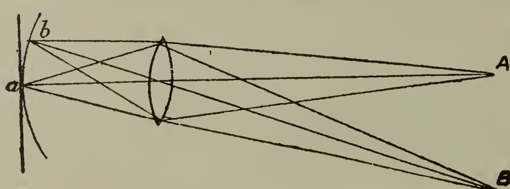


Fig 2

image of a certain size and brightness; through the smaller lens only twenty-five can pass, but as these form an image only $\frac{1}{4}$ the size of the other they will make it of equal brightness. Hence, stops which bear the same ratio to the focal length require the same exposure, whatever the focal length may be. One point about the action of a lens, comparatively little understood by photographers in general, is depth of focus, or the power of defining at the same time objects both far and near. Let these figures represent the same lens (Fig. 2 being more stopped down than Fig. 1), rays from *A* meeting in a focus at *a*, and rays from *B* at *b*.

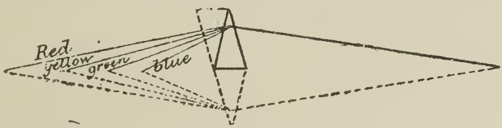
A screen placed at X as shown would be out of focus for objects at *A* and *B*, but if the points *d* and *e*, where the extreme rays meet the screen, be only $\frac{1}{100}$ of an inch. apart, the blurring will not be very noticeable. In Fig. 2 the extreme rays come together at a much smaller angle than in Fig. 1, owing to the smaller stop, and it is easily seen that the distance between *a* and *b* will be much greater than in Fig. 1, *d e* being in each case $\frac{1}{100}$ inch. The point *A* remains the same in each case, as it is the focus for distant objects, therefore in Fig. 2, *B* will be further away from the lens than in Fig. 1; the effect of this is to bring *B* nearer to the lens, that is to increase the depth of focus, which, in lenses of equal focal length, is thus dependent upon the diameter of the stop, and not upon the form of the lens. The words "equal focal length" have been used, as in the case of a lens of longer focal length, the points *a* and *b* would naturally be further apart with any given stop than in the case of a lens of shorter focal length, consequently the points *d* and *e* would also be further apart; but as $\frac{1}{100}$ in. is the maximum allowable, *b* must be brought back until *d e* is only that length, but bringing *b* back causes *B* to recede from the lens, which means that the depth of focus decreases as the focal length increases.

Another quality of lenses is flatness of field, a want of which is frequently attributed to a want of depth of focus, quite forgetful of the fact that this latter is always the same in lenses of equal focal length. It simply means that the images of objects the same distance from the lens are not all formed in the same plane



Thus while the image of *A* is formed at *a* on the screen, that of *B* is at *b*, some little distance from it, and on the curve, similarly the images of points between *A* and *B* lie on the curve. This, of course, leads to blurring near the edges of the plate, and as in the case of depth of focus, is worse as the focal length increases. Stopping down also remedies this defect, as it causes the lens to more nearly approach the condition of the hole in the tinfoil, which has a perfectly flat field. In ordinary landscape work the objects which are nearest the camera are generally considerably to one side of the lens (foreground, for instance), and being near, their images would be formed behind the screen were the field perfectly flat; its not being so, however, causes the image to be formed nearer its proper position; thus a certain want of flatness of field is generally an advantage, instead of otherwise.

We now come to one of the most beautiful things connected with the construction of a lens, viz., its achromatism. A ray of light, in passing through a prism, besides being bent out of its course or refracted, is also split up into the colours of the rainbow, technically "dispersed," as shown in full lines. Were another



similar prism to be added, as shown by the upper dotted prism, we should have another refraction and dispersion, but in opposite directions to those due to the first prism, so that the coloured rays would join together again and form a white one, which would proceed in its original direction just as if it had only passed through an ordinary piece of glass. Rays passing through a simple lens are both refracted and dispersed as by a prism, and, as can be seen by the aid of the lower dotted prism in the sketch, there would be one focus for the red rays, another for the yellow, and so on. The rays which give the most light, and consequently the brightest image, are the orange and yellow, while the actinic ones, or those which affect the sensitive plate, are mostly in and beyond the blue, therefore in such a lens the brightest image would be at one point, and the most chemically active one at another, so that, although the image might seem all right to the eye, to the sensitive plate it would be all wrong.

It was discovered that different kinds of glass had different powers both of refraction and dispersion, so that by putting two lenses of different shape and glass together, refraction could still be obtained, while the dispersion due to each nearly, but not quite, neutralised each other; such a lens is called an achromatic combination.

For purely optical work the glasses are so arranged as to give the best image for the eye to see, while the chemical image, being unimportant, is left to shift for itself. For photographic work, however, the chemical image must be made to coincide with the brightest one; hence the unsuitability of optical lenses for photographic work.

In conclusion, the following formula may be given as being of the greatest utility in all cases concerning the position and size of the image given by a lens: $\frac{1}{D}+\frac{1}{d}=\frac{1}{f}$, where D is the distance from the object to the centre of the lens, d the distance from centre of lens to the image, and f the focal length; any two of these being given, the third can at once be found.

Also, the size of object is to size of image (lineal dimensions) as D is to d.

LENSES.

Third Prize—J. H. TAYLOR.

ON consideration, it occurred to me that the use of stops, and several other points with regard to lenses, could be best explained, to the great majority of photographers, who have scant knowledge of mathematics, by the aid of a diagram, not drawn for mere purposes of illustration, nor by aid of mathematical calculation, but embodying the results of experiments made for the purpose of this paper, and with a lens of the highest class.

A camera and Dallmeyer stereoscopic view lens (18850) were taken, a scale of inches divided into tenths was drawn horizontally across the centre of the focussing screen, the zero of the graduation being on the axis of the lens. The lens tube and diaphragm were removed and replaced by a very short tube, which just cleared the lens, and carried close to its face a horizontal slide with a minute hole through which alone light was admitted. At a distance of 6 ft. from the lens, a line was measured at right angles to the axis, and points marked on this.

The figure (p. 40) represents to scale the lens-tube, diaphragm, and screen, and their relative position; but no attempt was made to determine the contour of the lens, which has been drawn from inspection. The line BB is the axis of the lens; rays marked A°, A', A'', α', α'' pass through the small hole when on the right margin of the lens; rays marked B°, B', B'', β', β'' through the hole when over the centre of the lens; C°, C', C'', when over the left margin; for clearness, only rays proceeding from the object on the axis or to the left of the axis are drawn. The lines A°, B°, C° converge to a point on the axis 6 ft. distant; A', B', C', to a point on the perpendicular to the axis through the point just mentioned, and 1 foot from the axis; A'', B'', C'', to a point 2 ft. from the axis; A''', B''', C''', to a point 3 ft. from the axis; α', β', γ', to a point $1\frac{1}{2}$ ft. from the axis; α'', β'', γ'', to a point $2\frac{1}{2}$ feet from the axis.

In addition to these observations, others were made when the small hole was midway between the centre and margin of the lens on either side, but these are not represented lest they should interfere with the perspicuity of the figure. The object was a circle of a bright light, forming a well-defined image just large enough to light the scale where it was incident. The screen is represented at that distance which made the image on the axial line BB most clear. All the other observations were made with the screen unmoved, since only the direction of the small pencil of light in each case was required. Frequent observations of the axial line were made to ensure that the camera was not moved from the initial position in which the axis cut the screen at the zero of graduation.

First it will be noticed that the rays B°B, C°C meet the screen in points $\frac{1}{10}$ inch apart; this shows at once that these rays should be cut off to prevent confusion; and it is obvious that rays from the point on the axis which strike the lens at points nearer the centre than A and C will intersect the axis nearer the screen than the rays B°B, C°C do.

Next consider the rays A′A, B′B, C′C. It is plain that A′A and B′B are nearer together at the screen than B′B and C′C, and that the C′C should be intercepted. Similarly C″C, *a fortiori*, should be intercepted as still further from the associated pencils B″B, A″A. It will be noticed also that the diaphragm (the fixed opening is represented) intercepts the pencil B′B, and admits only those which meet the lens between B and A, and so on for the other sets of associated pencils represented in the figure; and so tends to produce flatness of field.

Wherever rays from the same point of the object, after striking different points of the lens, converge, there they form an image. Were the whole lens uncovered, an infinite number of images of each point would be formed, some before, some on, and some behind the screen, in a given position; and the effect of those not on the screen would be, if near the screen to blur the image, and if *more remote*, to injuriously affect the sensitive plate. The object of the optician, therefore, is so to place the diaphragm as to admit the maximum number of pencils which converge on the screen. His task, however, is rendered more difficult by the fact that light is not simple, but composed of rays of colours of different degrees of refrangibility, so that if a lens of one kind of glass were used, the yellow rays, which most affect the eyes, would be brought to a focus further from the lens than the blue, violet, and ultra-violet rays, which affect the sensitive plate. By the use of two or more pieces of glass of different refractive indices and dispersive powers he endeavours so to arrange matters that the point of maximum illumination may be also that of maximum chemical energy. If he has not been successful in his attempt, the lens will never give sharp pictures until the error has been ascertained and allowed for. To ascertain whether the visual and chemical foci coincide, take a number of thin cards, bearing each the same conspicuous mark, and arrange them to overlap each other, so as to show the marks like the letters of an address book. Secure the system in a vertical position, and focus the middle letter. Expose a plate, and develop. If the middle letter is clearest (the slide having been proved true), the foci coincide for that point of the field; but if a difference be observed, measure its amount for an object at the mean distance at which the camera will be used, and alter the position of the ground-glass by packing up with paper or by deepening the rebate as may be necessary.

This will be found a better plan than that often suggested of turning the winch-screw or pinion to the requisite extent after focussing, since both pinion and screw are apt to wear loose at some part of their range, and besides, there is an opportunity of forgetting afforded by this method, while the suggested correction, though only approximate, is made once for all.

Note.—The term *actinic* is sometimes applied, as in the syllabus of the subject of this paper, to the luminous rays, sometimes to those which induce chemical change, and this forms one objection to the use of the term. Another is that the word is a derivative of the Greek equivalent of "ray," and therefore it should not be applied to rays of one quality only.

Spherical aberration is that property of lenses whereby rays dassing through their margins are more powerfully refracted, *i.e.*, brought to a focus nearer than those which coming from the same point pass near or through the centre. The diagram illustrates this. A simple mode of testing for spherical aberration is to cover first all but the centre of a lens, and note the distance of the screen when a distant object is sharply focussed, then to cover all but a narrow annulus concentric with the axis, and note the distance of the screen as before, and so on.

Curvature of the field is that property of lenses whereby rays from points in a plane perpendicular to the axis are brought to a focus nearer to the lens as the points are taken further from the axis; the rays being incident on the same part of the lens in each case. This property also is illustrated by the diagram.

Barrel-shaped distortion produced by view lenses is due to the fact that the margin of the lens refracts more powerfully than the parts nearer the centre. Hence the more distant parts are focussed nearer to the axis than they should be proportionally, if the stop be in front of the lens, and *vice versa*. This can be well seen for himself by any one who will take the trouble to make a few simple experiments. If, with a slide as described above, and the small hole in any position near the margin of the lens, one watches the image of a small bright globe which an assistant moves steadily away from a point on the axis of the lens. at some little distance from the camera, along a line at right angles to the axis towards the left, the image on the focussing screen will be seen to travel slowly towards the right for some distance, and then to return upon its path. This shows that the image of a point more distant from the axis of the lens, the rays from which can fall only near the margin of the lens, will be formed at a point nearer the centre of the screen than the image of a point less distant from the axis. So that if the line at right angles along which the light is moved be the diagonal of a square which one wishes to photograph as large as possible, it is plain that in place of getting the figure a square as at *A*, one will get the distortion *B*. If the stop be behind the lens the distortion will be as

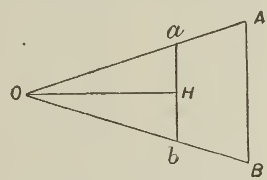

A *B* *C*

in fig. *C*. The opposite distortions produced by a stop before or behind a single lens are corrected by placing a lens on each side of a stop, the arrangement of rectilinear and symmetrical lenses.

Flare and Flare Spot.—When a diaphragm in front of a single lens is used, the pictures are sometimes disfigured by a circle of light more or less clearly defined. Everyone is familiar with the multiple images of a candle seen on looking along a mirror at a candle placed near it. These are caused by internal reflections of the rays between the front and back surfaces of the glass. Similar reflections of part of the light which is incident on the outer surface take place between each pair of surfaces of a lens, and when a view lens with front stop is used, a common cause of flare is that part of the light transmitted by the front surface is reflected by the second back on to the front surface, and there reflected, and by its curvature concentrated and focussed on the sensitive plate. An alteration in the position of the stop will prevent the focus being formed on the surface of the plate, and thus remedy the harm by diffusing the doubly reflected light.

I have found two other causes of flare in lenses of my own. First, the reflection of light from the edge of a stop which was of sensible width ; reducing the opening, with a rose bit, to a feather edge, and reblacking made all right. Next, what used often to be a subject of complaint, reflections from the bright ground margins of the lenses. These reflections should be cut off by diaphragms of wide opening pushed close up against the lenses from behind. If, however, the diaphragm be between two lenses, the explanation of the cause of flare is somewhat different. In this case part of the light transmitted by the diaphragm is reflected, as by a mirror, by the inner surface of the inner lens, back through the opening, and then similarly reflected and concentrated by the outer surface of the outer lens in such a way that part of it, after this second reflection, is transmitted by the second lens, and focussed on the sensitive plate. In this case change of the position of the diaphragm renders the mischief less noticeable by softening the outline of the circle, but it introduces other evils of distortion and curvature of field. It is preferable, therefore, to alter the distance between the lenses, letting the stop keep the ratio of its distances from them. This alteration prevents the doubly reflected rays from being brought to a focus on the sensitive plate.

Focal Length.—The focal length of a simple lens is the distance at which it brings parallel rays to a focus. The equivalent focus of a combination is the distance at which a thin, simple lens would form an image of an object of precisely the same dimensions as the combination does, the distance of the camera from the object remaining unaltered. To find the equivalent focus of a combination, attach the camera to a fixed horizontal drawing-board or table, and notice the extreme lateral points of the view. Draw a vertical line through the centre of the screen,



and turn the camera on its screw so that first one and then the other lateral limit falls on the vertical line, and in each position draw a line on the board along the edge of the camera. These lines give the angle of view. Let OA, OB be these lines; take OA = OB, and join AB, and insert a line *a b* parallel to AB, and equal to the width of the screen; draw OH perpendicular to *a b*. OH is the equivalent focus. The above method is due to Mr. Thomas Grubb.

The following was suggested by Mr. J. H. Dallmeyer:—Find the solar focus of a thin spectacle lens, then place this lens in a camera and focus any object, and accurately measure the length of the image; then focus the same object at the same distance, and measure the length of the image. These lengths are directly proportional to the focal distances. Thus $d' : d'' :: l' : l''$; hence d'' the equivalent focus of the combination is known, being equal to $\frac{d' \, l''}{l'}$.

Depth of Focus.—If with a quarter-plate camera, having a scale on its baseboard, an object be focussed at successive distances, *e.g.*, 5, 10, 15 yards, it will be noticed that the distance between successive positions of the screen rapidly diminishes as the distance of the object increases, so that after a few measures are taken the movement becomes very small or negligible. With a half-plate or whole-plate lens a similar diminution of the distances would be noticed, but the distances would be greater, and the difference would not so soon become negligible. In other words, it would be found that from a certain distance not itself great all objects beyond would be in focus with a short-focus lens, but that with a long-focus lens this result would not be obtained unless the nearest object was considerably further off. These observations would have shown you that short-focus lenses have much greater depth of focus than long-focus lenses. A consequence of this is that enlargements from a negative taken by a good quarter-plate lens may give a more pleasing picture than one taken by a larger size direct.

Landscape Lenses.—Single lenses, which on account of the distortion they produce are not suitable for architectural subjects, give the most brilliant pictures, because they have fewest reflecting surfaces. Excellent portraits have been taken with them when the conditions of light, etc., were favourable. The best form of single view lens is Dallmeyer's, in which a flint-glass lens is enclosed between two of crown glass, which are much less liable to injury.

Architectural Lenses.—For architecture or copying, double combinations are essential, in order to reproduce straight lines. The best lens is that which with a stop of greatest ratio to its focal length will give the sharpest picture, and in the shortest time. Beginners often make the mistake of supposing that equality of all measurements makes the lens of an unknown maker equal to one by a Dallmeyer, when trial would probably show that the pictures taken by the unnamed lens will not bear enlargement, or that the lens works slower, being constructed of inferior glass, which absorbs an undue quantity of the light incident upon it.

Portrait Lenses.—The double combinations used for architectural subjects and copying are constructed to take objects at very different distances with great sharpness, and, therefore, have comparatively small diaphragms. Portrait combinations being used for objects not far removed, but of which the distance of the furthest and nearest points bears a high ratio to the distance from the camera, require considerable depth of focus. They must work quickly, and, therefore, both are of large diameter, and have stops bearing a high ratio to their focal length. To secure depth of focus, Mr. J. H. Dallmeyer, in his excellent lenses, arranged that this might be done more or less at will by separating the components of the back combination. This secured a softly rounded rendering of a head, instead of giving one point microscopically sharp and the rest blurred.

Wide-Angle Lenses.—In using wide-angle lenses care should be taken not to include any more of the near foreground than can be avoided, since the distance is dwarfed in comparison.

Correct Centering.—To test for correct centering, most important in combinations, have a new flange made carrying a piece of tube within which the mount of the lens may just turn (the writer uses this arrangement to take the shock of any shutter off the lens' mount); focus a small object on cross lines at the centre of the screen; then give the lens mount half a turn, and refocus. Displacement of the image will show error in centering. If there were great error, it might be found by noting the positions of the image of a small object formed by the two lenses used separately. If the two positions do not coincide, there is an error. This method postulates thorough accuracy in the camera.

A lens, in use, should be carefully screened from all rays not coming from the object. Lenses should never be allowed to stand exposed to sunlight, which sometimes impairs their translucency.

Lenses should be kept in a dry place, and protected at each end of the mount by caps. If they become dusty or dulled, they may be cleaned by breathing on them and rubbing with a soft silk handkerchief, which after well washing has been thoroughly rinsed from soap and dried. If the deposit does not readily yield to this treatment, sulphuric acid diluted with four parts of water might be tried, and followed by the application of dilute ammonia, but in such a case it will be far safer for the average amateur to return the lens to the maker to be cleaned.

COMPETITIVE PAPER No. III.

SHUTTERS.

First Prize—W. GROVES.

PHOTOGRAPHIC shutters may be defined as mechanical arrangements for effecting the exposure of sensitive plates or films.

Their chief use is to effect the minute exposures required in the practice of what is termed instantaneous photography, but they are not confined to this purpose.

A shutter should be (1) free from vibration, (2) adjustable to give various definite exposures, (3) adjustable to vary the relative exposures given to the foreground and sky, (4) portable, (5) simple in construction, (6) should occupy as small a portion as possible of the exposure in opening and closing, and (7) should not be liable to be easily damaged.

Of the above, 1 and 2 are essential, and their absence is fatal to the value of any shutter.

Vibration may be minimised by making the moving parts light, using weak actuating springs, counterbalancing moving parts by oppositely moving parts of equal weight and velocity, and by using suitable means for setting the shutter in action, such as one of the forms of pneumatic release. It should be remembered that whenever a part of a structure such as the slide of a shutter is set in motion, the rest of the structure tends to move in an opposite direction with a velocity inversely proportional to its mass, and that the shock produced by suddenly arresting a moving part, such as the slide of a "rebounding shutter," varies directly as the weight of the slide and the *square* of its velocity. Thus, if the velocity of the slide be doubled, the shock produced in suddenly arresting it is increased four times. In most revolving shutters with an exposure aperture, shake is produced by centrifugal force, which is unbalanced on account of the removal of the material to form the aperture.

For marine work, in addition to the features enumerated above as "essential," a shutter should be capable of giving the most rapid exposures, and should preferably for obvious reasons protect the lens from spray, offer a small surface only to the wind and be formed of material which is not liable to corrode, become deformed, or swell through the action of moisture. A shutter for use at the seaside should not be liable to jam or become deranged through the presence of particles of sand or dust, which it is almost impossible to exclude from its working parts. This is a serious defect, to which all shutters with well-fitted rigid sliding parts are liable.

In landscape work an important special feature required is the power of varying the relative exposures given to the foreground and sky.

For photographing rapidly moving objects, such, for instance, as shots as they leave guns, extremely rapid shutters, set in motion at the desired instant by the objects themselves, are necessary. Rapidly moving projectiles have been caused to complete electric circuits for releasing shutters at the desired instant.

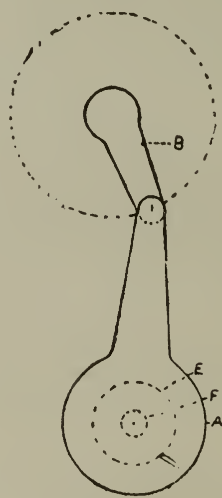
Shutters may be used (1) before the lens (generally on its hood), (2) in the diaphragm slot of the lens, and (3) somewhere between the lens and sensitive film. In the first of these positions no alteration is required in the lens or camera, and the shutter is readily attached, removed, and adjusted. Here, also, more exposure may be readily given to the foreground than to the sky by suitably shaping the apertures in horizontally sliding and rotary shutters to give more exposure to the bottom than the top of the lens; by causing the lens to be uncovered by a slide or hinged flap rising vertically, and afterwards covered by the return of the same or another slide or the return of the flap; or by attaching a sky shade (preferably adjustable) to the upper portion of the opening of the shutter, to cut off a portion of the rays from the sky. The chief drawback is that shutters on the lens hood are in the position most favourable for causing the camera to shake. But as there are plenty of cheap and compact shutters sufficiently free from vibration, this seems to me to be the most favourable position for ordinary purposes.

In the second position, the shutter, whatever its form, and whether opening centrally or from one side of the lens, has little or no effect on the equality of illumination of the sensitised film, and since the section of the bundle of rays of light is less here than elsewhere, the moving parts of the shutter can be made extremely small, and the risk of vibration consequently diminished.

A decrease in the size of lens stop used causes a decrease in the time of exposure given by a "diaphragmatic shutter," in which the range of motion of the exposing part is constant. In the Grimston shutter, for instance (see fig., p. 62), a disc or plate, *A*, in the diaphragm slot is withdrawn and returned by a rotating crank, *B*; the travel of *A* is therefore equal to twice the length of the crank *B*. It is obvious that of two stops, *E F*, the smaller, *F*, would be opened later and be completely closed earlier than the larger, *E*.

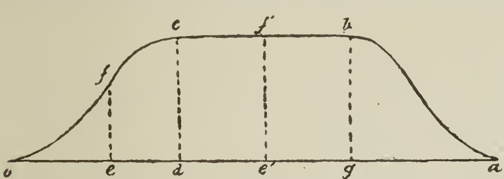
Taking this into consideration, it is a very nice problem to decide the manner in which the stops should be varied to definitely vary the exposures. In addition to this difficulty concerning the stops, lenses have generally to be adapted to receive these shutters, and they are costly.

In the third position two cases will be considered, viz., that in which the shutter is near the lens, and that in which it is immediately before the sensitised film. When near the lens, the shutter requires to be of much the same size as when used before the lens, and variations in the exposure of the foreground and sky can generally be effected by properly shaping the shutter aperture. The "simple drop" shutter, when used behind the lens,



gives slightly more exposure to the foreground than to the sky, the contrary being the case with it when used before the lens. Shutters used immediately in front of the plate permit the full power of the lens to act on each portion of the plate during the whole time the said portion is uncovered. By using a drop shutter or roller-blind shutter with a narrow aperture the width of the plate, it is probably possible to give shorter exposures and obtain sharper images of objects than with shutters in other positions. In the case of rapidly-moving objects the images obtained by these shutters are slightly bent or distorted, as will readily be seen when it is considered that the image is exposed bit by bit as it travels along the plate. This distortion may be reduced to a minimum by causing the shutter to travel in a direction opposed to that of the image. Variation in the exposure given to the foreground and sky may be effected as in shutters immediately behind the lens. Shutters in this position become very bulky for the larger sizes of cameras; their exposure apertures have to travel over a large amount of space, and, as in the case of shutters immediately behind the lens, they require to be especially fitted to the camera. Shutters behind the lens are particularly adapted for hand or detective cameras.

Since shutters permit the full aperture of the lens to act for a portion of the exposure only, the photographic effect on the plate of an exposure is not correctly indicated by the time of movement of the shutter. To correctly estimate this effect we must multiply the amount of light admitted (or its equivalent, the amount of lens open) at each portion of the exposure by the time for which it acts, and add together these products. The total effect of an exposure may be exhibited by the area of a diagram *o c b a*, in which *o a* represents the whole time the lens is open, and ordinates such as *e f*, *e′ f′*, the areas of the portions of the lens open at corresponding times, *o e*, *o′ e′*, from the commencement of the exposure. In this diagram the line *c b*, parallel with *o a*, indicates the time for which the full opening of the lens aperture was permitted to act, and the rectangle *b c d g* the effect produced on the plate during this time, while the areas of the end portions *o c d* and *a g b* respectively represent the effects produced during the



opening and closing of the lens. The setting out and calculation of the areas of these diagrams is a matter of considerable difficulty in most cases.

Admitting that the effects produced during opening and closing of the lens are equal, the total effect is given by—

$$\text{Effect of shutter} = 2\int_0^{od} A'dt + At',$$

where A' is the area of the portion of lens open at any time, t; *o d* the time occupied in uncovering the lens; A the area of the aperture of the lens employed in the exposure; t' the time for which the full area acts.

The effect of an exposure may also be represented as shown by the volume of a cylinder of cross section *a e c x*, equal in area to the lens aperture, and in which the lengths of ordinates such as $h\ g\ h'$ drawn from the upper to the lower end represent the times for which corresponding points g in the lens were in action. In the example shown the volumes of the end segments $b\ d\ k$ and $n\ m\ l$ respectively represent the effects produced while the lens was opening and closing, and the intermediate cylinder $d\ k\ m\ l$ the effect produced while the full opening was in action.

Different shutters working at the same speed have very different effects on the plate, owing to the difference in time spent in opening and closing, but their effects can be compared by finding their "equivalent exposures."

The "equivalent exposure" of a shutter exposure has been defined to be the duration of the exposure which with the lens fully open will have the same effect on the plate as the exposure given by the shutter.

The nearer the actual time of exposure of the shutter is to the "equivalent exposure" the more efficient the shutter.

The following are examples of equivalent exposures, T in each case being the time of the exposure given by the shutter in question.

(1) Shutter with circular hole expanding from centre of lens to circumference, and closing again at a uniform rate. Equivalent exposure $= \frac{T}{3}$

(2) Sliding shutter with square aperture, with side equal to diameter of lens, and moving across lens with uniform velocity. Equivalent exposure $= \frac{T}{2}$

(3) Same form of shutter and conditions as in (2), but with rectangular aperture of length equal to three times diameter of lens. Equivalent exposure $= \frac{3}{4}$ T.

Example (1) represents the performance of shutters of the Iris diaphragm type, and approximately those of the Sands and Hunter type, while (2) and (3) represent approximately the performance of shutters of the roller-blind and drop types, Example (3) shows the increase of efficiency obtained by lengthening the exposure aperture.

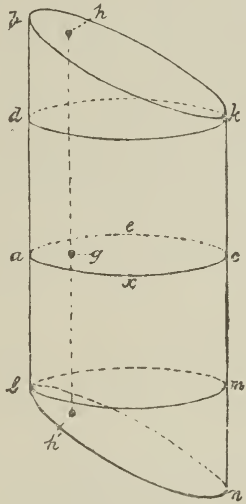
Perhaps the performance of a shutter could be more conveniently estimated by comparing its effect with the effect produced by the lens when fully open, and acting for the same time. We should then have

$$\text{Efficiency of shutter} = \frac{\text{Effect produced by shutter}}{\text{Effect produced by unobstructed lens acting for same time.}}$$

The results would be fractions, which in the above examples would be $\frac{1}{3}$, $\frac{1}{2}$, and $\frac{3}{4}$ respectively.

Space will permit me to refer but briefly to a few of the more simple forms of shutter.

Perhaps the simplest and cheapest is the time-honoured "drop. It consists of a slide working in grooves, and provided with an aperture which is preferably made of adjustable length. When released the slide drops under the action of gravity, and the aperture passes before the lens, thus effecting the exposure. It is easily made, not liable to get out of order, comparatively free from shake during the exposure, can be bought from a few



shillings upwards, and for most purposes is as good and efficient as any other form. It gives slightly more exposure to the foreground than sky when used before the lens, but this defect can be remedied by attaching a sky shade to the upper portion of the opening.

Neglecting friction, the time during which a drop-shutter exposes the lens, can be calculated by the formula:

Time in seconds $= \{\sqrt{h+d+a} - \sqrt{h}\} \times \cdot 072$.

Where h = height of bottom edge of shutter aperture above top of lens aperture in inches before the release of the shutter.

a = diameter of lens aperture in inches.

d = length of shutter aperture in inches.

Example: Let $h = \frac{1}{4}''$, $d = 3'$, and $a = \frac{3}{2}''$.

$$= \cdot 072\{\sqrt{\tfrac{1}{4}+3+\tfrac{3}{2}} - \sqrt{\tfrac{1}{4}}\} = \cdot 072\{\sqrt{\tfrac{19}{4}} - \tfrac{1}{2}\}$$

$$= \cdot 072\left\{\frac{4\cdot 358-1}{2}\right\} = \cdot 072 \times \frac{3\cdot 358}{2} = \cdot 036 \times 3\cdot 358$$

$$= \cdot 1209 = \frac{1}{8\cdot 2} \text{ seconds.}$$

The drop-shutter, assisted by elastic bands, can with a fairly long aperture be easily caused to give exposures as brief as $\frac{1}{30}$ or $\frac{1}{40}$ of a second.

A valuable shutter, and my favourite, is the Kershaw shutter. In this a flexible opaque band with an aperture is, when released, wound up by a spring roller similar to that of a blind, thus causing the aperture to pass before the lens and effect the exposure. This shutter is moderate in price, very compact, and the blind being light a weak propelling spring only is used, thus obviating all perceptible shock. It is not liable to stick or jam during an exposure through the action of sand or dust, and a long aperture can be used, thus permitting the lens to be open during a large proportion of the exposure. Speeds ranging from about $\frac{1}{100}$ to $\frac{1}{25}$ of a second are attainable. Variation in the exposure of the foreground and sky might be effected by attaching a sky-shade to the upper part of the aperture.

In another simple shutter a slide is shot from before the lens by an elastic band, and returned by a second elastic band. This, though extremely cheap and compact, and capable of giving considerably more exposure to the foreground than the sky, is very liable to blur the image, since it strikes the returning elastic band when the lens is fully open, causing a shock which increases directly as the square of the velocity of the slide and its weight.

Forrest's "Due-ratio" drop shutter possesses the advantages of the one last described, except as regards cost, and is constructed to avoid vibration. A slide or plate when released is raised from before the lens by a second slide, which descends and covers the lens. The slides are connected by cords passing over the top of a partition which separates them, and the descending slide may be propelled by a weight or spring to give very rapid exposures.

Shutters which open in a gradually expanding aperture or hole from the centre of the lens towards the circumference, and close again towards the centre, give perceptibly more exposure to the centre than to the edges of the plate when used before or behind the lens, but of course do not possess this defect when used in the diaphragm position.

Shutters with a revolving circular plate containing an exposure aperture, such as the Lancaster shutter, are fairly compact, and work satisfactorily in the small sizes, but as the side of the disc opposite the aperture is generally the heavier, there is a tendency to produce shock through the operation of centrifugal force in the larger sizes at high speeds.

In a good many shutters elastic bands are used to propel the moving parts. Their use should be avoided as far as possible, since they rapidly deteriorate in elasticity, thus rendering it impossible to use the shutter intelligently.

There are shutters supposed to be capable of being set to give minute definite time exposures. This is a great desideratum, but as such shutters are generally complicated and expensive, and it is obvious that a small variation in a propelling spring, a slight alteration in any part by wear, etc., or the presence of grit or dust in the working parts would make a considerable difference where such small times are concerned, I do not think they can be recommended.

To be certain of obtaining good results with any shutter, it is absolutely necessary to become acquainted with it by carefully using it and noting its performance under varying speeds and conditions.

I regret that want of space has compelled me to unduly contract some portions, and to omit all mention of other portions of this important subject.

SHUTTERS.

Second Prize—J. H. TAYLOR.

In this paper the objects to be held in view in the construction of photographic shutters will first be stated, and some general remarks made on the conditions of construction of a perfect shutter; next the effect of the position of the shutter will be explained; and lastly, account will be given of the performances, merits, and defects of different kinds of shutters.

When objects in very rapid motion are photographed under the most difficult conditions, *i.e*, when they are crossing the field of view at right angles very near the camera, so that their angular velocity is very great, the sharpness of the picture depends on the total time from the beginning of uncovering to the end of covering the lens; the clearness of the resulting picture, and the ease of development depend on the quantity of light admitted during that time.

To secure sharpness, then, the whole time must be very brief, the total length of exposure being absolutely limited by the angular velocity of the object. To secure clearness and ease of development, the maximum quantity of light must be admitted during the brief time to which the velocity of the object limits the duration of exposure, and this can only be effected by so subdividing the brief total length of exposure that the actions of uncovering and recovering the aperture may be as small fractions as possible of that brief total. Further, since all objects do not travel with the same angular velocity, it is desirable that these times be adjustable, to facilitate development in cases in which slower movement of the object allows less rapid exposure.

Why is it difficult to attain these aims? Because for the production of extremely rapid movements of the leaves of the shutter, very light though they be, forces must be employed which are very great in comparison to the weights to be moved, and unless these forces are carefully balanced shocks will be caused, and unless the weights to be moved are so disposed that no movement of the centre of gravity of the whole apparatus takes place, tremors will be induced which will prove fatal to success. Sometimes this result is brought about by a badly designed release.

NOTE.—Here it may be remarked that the leaves of the shutter may be made much lighter if the forces act by tension than if they act by pressure, for then both the leaves themselves and any links used in the construction must be strong enough to resist compression. This consideration affects all go-and-return shutters, *e.g.*, the Plunge shutter. Most shutters commence to uncover from rest, or, owing to a slight overlap of the leaf or leaves, almost from rest; but they would act better if a longer overlap were used, so that the leaves might be in rapid motion before they begin to uncover the lens. This advantage is attained in all "go-and-return shutters," such as Newman's Pneumatic, the Plunge, Gotz Volute, Grimstone's, etc., when a stop smaller than the full opening is used, and at the same time the duration of full opening is made a much larger fraction of the whole time of exposure.

But in shutters of this type, when the full opening of the diaphragm is used, the shutter is only momentarily full open, while the crank pin, at its dead point, changes from drawing the leaf off to driving it on. This momentary rest is in no way injurious to the action or life of the shutter.

Very different, however, is the case of any shutter in which the leaves are absolutely at rest for a large fraction of the whole time of exposure, and are then rapidly driven to close the opening. Here there is a serious error of design, which must prove absolutely fatal either to the rapidity of the shutter, or to its continued use for a reasonable length of time, since the excessive strains due to the sudden closure of the leaves by impact from rest, will render the works liable to give way at any moment.

Shutters for marine work must be of the most rapid kind, for though vessels do not move nearly so rapidly as express trains, yet owing to their rolling and pitching, the composition of velocities makes the movement of the upper rigging extremely quick. Moreover, the light is always purer and more powerful to induce chemical change on or near the sea than it is inland.

Shutters for marine work must also be constructed of material either not liable to injury from salt spray or else wholly boxed in from contact with it.

For ordinary work all that is required is for the shutter to open quickly, smoothly, and without jar, and to close similarly when required.

For taking young children and animals, and for portraiture in general, it is very desirable that there be no click at opening, and that no movement be visible. Guerry's shutters have been much used for this purpose, since they act silently within the camera.

PLACE OF THE SHUTTER.—To ensure quickness of action there can be no doubt that the position of the diaphragm is the proper place for a shutter, for there the area to be covered is least; and, as we shall show presently, this is the best position for admitting light from all parts of the field at once.

. To ascertain the effects of different modes of opening of shutters, experiments were made with a Dallmeyer 8 by 5 R.R.

Extra blank diaphragms were prepared, and small holes of $\frac{1}{10}$ in. diameter were made, one in each blank, so that when inserted in the slot they might occupy the following positions on a vertical diameter:—

A touching the circumference of the fixed stop at the lowest point, B midway between A and the centre, C at the centre, D midway above the centre, and E diametrically opposite to A. These holes admitted light to the screen as described below.

A	from	18° 26′	above the axis	to	15° 9′	below the axis.	
B	„	23° 47′	„	„	23° 30′	„	„
C	„	22° 37′	„	„	22° 37′	„	„
D	„	23° 30′	„	„	23° 47′	„	„
E	„	15° 9′	„	„	18° 26′	„	„

The stop *f*/9 let in light from all these holes.

„ *f*/11 half covered the marginal holes, A and E.

„ *f*/12 just coveredthe marginal holes, A and E.

It is not worth while to consider the small stops which could not be used for instantaneous work.

From the above figures it appears that on the first lifting of a Newman shutter *in the diaphragm slot*, rays are admitted from points lying between 18° 26′ above the axis of the lens to 15° 9′ below the axis, but not from the whole of either sky or foreground. When, however, the shutter has been lifted a little higher, rays are admitted from all parts of the field. If, however, the second or third stop be used, light is admitted from all parts of the field at the first uncovering. These remarks apply to all "go-and-return" shutters working in the diaphragm slot. A consequence of this is that with a diaphragmatic shutter it is a matter of perfect indifference how the uncovering and recovering is effected.

In making observations with the fine holes as described above, two phenomena cannot fail to attract the attention of the observer: (1) If a bright steady light be moved slowly across the field, there are several points at which the image is brighter than in intermediate positions: (2) When a hole near the circumference of the fixed stop is used, as the light recedes from the axis of the lens, the image on the screen at first travels steadily towards the opposite side of the screen, and then returns upon its course for a short distance before it finally disappears owing to the rays from the light being intercepted by the hood of the lens.

The determination of the intensity of the light admitted at any angle would be a work of great difficulty; the occurrence of maxima and minima of intensity seems to point to interference of partially polarised rays, and to require appeal to the wave theory of light for its elucidation. Both points are therefore passed over as beyond the scope of this paper.

If a shutter in front of a combination be *slowly* lifted it will be noticed that the image on the screen brightens from above downwards, *i.e.*, the foreground has rather longer exposure than the sky. If a shutter behind the combination be used, the effect is reversed.

In either case it is plain that the shutter has a greater area to uncover and cover than it would have at the diaphragm slot, and therefore that it must be at a great disadvantage as regards rapidity. The best sky shade would be a light curtain of adjustable travel working immediately in front of the sensitive plate, or a very light screen might be made to vibrate at some little distance behind the back lens, either under the action of a very short pendulum of sufficient weight to keep it in movement for a brief space of time, which arrangement would not suit very light cameras, or else worked as an adjunct to the mechanism of the shutter. "At some little distance," because the further you go from the lens the less risk there is of intercepting other rays than those which it is desired to intercept.

A Grimston's shutter, working in the diaphragm slot of a Ross R.S. 5 by 4, gave on its first trial a picture of a lawn-tennis set, with the ball in the air, but this was at a distance of eighty feet, and the hands and feet of the players were not sharp. The spring gave way after a few trials, and this failure has been several times repeated.

A Reynolds and Branson's shutter, used with a Dallmeyer R.R. $8\frac{1}{2}$ by $6\frac{1}{2}$, on the hood, proved a very convenient and useful shutter for brief but not extremely rapid exposures. It is, however, a rather cumbersome piece of apparatus to carry about, and one which, as experience has shown, is easily deranged. Its rate is not constant; nor is the rate of any shutter which is driven by india-rubber bands. It has, however, this great advantage, that, owing to its combined use of a flap and a drop, the foreground receives more illumination than the sky. This advantage would be increased if the flap worked between side pieces, sectors of a circle, to cut off rays that may strike the lens mount from beyond the field of view.

Kershaw's Shutter.—The great merit of this shutter is its simplicity, lightness, and cheapness, advantages which it owes to the use of tension. I have not used this shutter, though I some time ago made some trials with a home-made shutter very nearly identical in design, and proved its speed.

Newman's Pneumatic Shutter.—This shutter, *when well made*, is an excellent one for giving the power of reproducing exactly the speed which you have found to be sufficient for the purpose in hand. It is, however, not quick enough to take an express coming in to a station about 150 yards distant, though one which had left, taken from the same point, was fairly rendered. In another picture two feet and legs of a horse, 46 yards off, taking a tramcar round the curve connecting two straight runs at 120 degs., are far from sharp, but a man walking away from the camera, at a distance of 17 yards, shows less sign of movement. This shutter, after a few trials, suddenly failed in the middle of an exposure. On examination, it was found that the spiral spring, having too much lateral play, had overlapped its coils and jammed itself. When this accident is made impossible, there is no better shutter than Newman's for the purpose indicated above.

Flap Shutter.—This very simple shutter, which should play between side wings, worked by hand by means of a milled head on the axis of suspension, gives excellent results, which cannot be surpassed, but very great delicacy of handling is necessary to avoid shaking the camera. This risk may be in great measure avoided by employing a coupling of Hook's joints, or a flexible shaft as in the Leicester exposing flap and shade of Messrs. Taylor, Taylor, and Hobson, which, however, I should like better, if it were made square, to work between side wings, as described above.

The Drop Shutter.—The drop shutter, with a long adjustable slot, in theory gives the stated requirements of rapid uncovering and recovering, and relatively long duration of time of full exposure of the lens. But the calculations for variation of time of exposure are not simple, and the apparatus, if constructed to work by gravity alone, would be very cumbrous; while if, as is generally the case, india-rubber bands are employed to accelerate the action, these bands are variable in strength and very prone to give way without warning. Finally, the shock of the stoppage of the slides is very injurious to the lens mount.

Sands and Hunter's Shutter, and Shew's Shutter.—These shutters, which, using two leaves, uncover the lens from the centre, and close to the centre, act as stops of a mean diameter, and thus render the picture sharper than it would have been if taken by a "go-and-return" shutter, by which precisely the same quantity of light was admitted.

Wollaston's Shutter.—The great weight of this shutter is against its general use, as is the case also with other clock-work shutters.

Prosch's Duplex.—This American prize shutter is far the best that I have used. Two leaves pivoted a little distance apart uncover the lens by a vertical line across the centre of the diaphragm. They uncover and then recover, moving continuously in the same direction. My first trial of this shutter, using the weaker of the two springs supplied with the shutter, in the fourth hook of the rack, gave me a picture in which a dog-cart driving quickly past, and its shadow, are sharply rendered. Since then market and street scenes and breaking waves have been successfully taken with it, and at 1.30 p.m. on October 1st a train running through Huntingdon Station at a little over 62 miles per hour. This, however, was taken at an angle of about 30 degs., and with the aid of a special diaphragm which shortened the exposure at each end. This shutter, however, has the defect of almost all shutters, that the duration of full opening is only momentary, and that the leaves sweep on with constantly accelerating velocity from the beginning to the end of the exposure, and, finally, that at the end there is a great shock to be suddenly borne by the lens mount.

Plunge Shutter.—I have seen a series of pictures taken with a Plunge shutter which all gave a double outline to every object. The cause was, I believe, that the shock of the reversal of the action of a solidly constructed shutter used on a very light camera caused a slight displacement of the camera as a whole, or of the front frame, and so marred the pictures.

I have not seen or heard of any shutter in which all the conditions necessary to success have been kept in view in the design. Many of the shutters which are in practice found to give good results in small sizes would be found in fault if tried in large sizes on very light-built cameras.

Comparison of the Equivalent with the Actual Exposure.—Any comparison of the equivalent and actual exposure starts with the grand assumption that wherever an equal area of the diaphragm is open, an equal quantity of effective light is admitted, which is far from being the truth. It may be readily shown that a shutter which moves with uniform velocity gives a more favourable result than one which, travelling under the influence of a constant force, starts to uncover from rest, moving with constant acceleration, the whole time of both shutters being the same. Almost all shutters start to uncover from rest, but the force acting is not constant, though the more the spring is wound up, as in Grimston's shutter, the nearer the case approaches to one of a constant force. After the shutter has moved over one-fourth of its distance, the time between any two points is longer on the supposition of uniform velocity than on that of constant force, *i.e.*, more light would be admitted during that part of the opening. Between the end of the first quarter and the end of the third quarter of the travel—the part in which the greatest area is exposed—the time under constant force is only about ·732 of what it would be at constant velocity, and if we calculate the ratio of the sums of the areas exposed for each element of time of its travel to the whole area exposed for the whole time in the case of constant velocity, we find that the result is about ·5, so that we may safely conclude that when the movement takes place under the action of force, which, though diminishing, produces a constantly increasing velocity of the leaves, the effect cannot be better than the opening of one-third of the area for the whole time, and that it is probably not even as good as the opening of one-fourth of the area for the whole time.

The cases in practice, however, are not, except in the drop shutter, cases of rectilinear movement, but of movement produced by crank pins, and in consequence the mathematical expressions for the areas are complex integrals which require many figures and considerable time for their solution.

The rate of opening and closing of any shutter might be practically determined as follows:—A shutter of the kind to be tested should be made of a large size and furnished with a weak spring.

The shutter should then be placed before a narrow slit in a metal plate, through which a beam of parallel rays of bright light, *e.g.*, sun light, would pass through the shutter when open; the slit being parallel to the direction in which the shutter opens. Behind the shutter a sensitive plate should be made to travel at uniform velocity across the shutter. The result will be a figure of the above type, in which if AB be divided into any integral number of equal parts, n, and perpendiculars be drawn at the points of section, the distances measured along AB will represent equal intervals of the whole time of exposure, and the ordinates will show the amount of opening of the shutter at that time. Then the amount of opening being known, the area open at that time can be calculated, and the sum of the product of each area, and the time for which it is exposed, can be made out, and divided by the product of the whole area by whole time, which is the ratio required.

The assumption in this mode of obtaining the result is that the shutter under the force of a weak spring would undergo exactly the same phases of movement that it would undergo in a shorter time under the force of a strong spring.

SHUTTERS.

Third Prize—LOUIS MELDON.

Shutters may best be classified relatively to the position they occupy when used with the ordinary form of doublet lens—1st, on the hood of the lens; 2nd, between the two combinations; 3rd, immediately behind the lens; 4th, immediately in front of the plate.

The fourth class I intend at once to dismiss; for although its position is in many respects the most favourable of all, these advantages are much outbalanced by the inconvenience due to the large size of the apparatus needed, which is sufficient to condemn the principle for practical utility.

Every shutter will vary its effects according to which of the above positions it occupies. I will, therefore, endeavour to point out these different effects. Let me, however, first define a few terms, and lay down a few general rules.

An "ideal" shutter is one which, if it were possible, would open to its full aperture suddenly and without lapse of time, and having remained open a certain time, would close thus suddenly again. Such a shutter would possess the summit of efficiency, but is impossible of construction, and is only spoken of as a standard for comparing other shutters. It is right to make such a shutter the ideal of attainment, generally speaking, although for a certain class of shutter, working within certain limits of speed, as I shall point out, a shutter of low efficiency will give far better results.

The word "efficiency" as applied to a shutter has a special meaning, viz., the ratio which the total amount of light which passes through the shutter during exposure bears to the amount of light which would pass through the lens if wide open during the full period of the same exposure.

The equivalent exposure of a shutter is the period of exposure necessary with an ideal shutter, or with a lens wide open, in order to affect the plate with an exposure equal to that of the particular shutter under comparison—for example, take a particular shutter, one of those which I will speak of later, speed $\frac{1}{20}$ second. The full lens aperture is open only a very brief period of exposure; during the rest of the time the shutter is either opening or closing. The apertures varying in intensity, the sum total of light admitted by the shutter to pass the lens in $\frac{1}{210}$ second is a given quantity. Now, if the lens were open the whole time, I estimate that an exposure of $\frac{1}{657}$ second would exactly admit the same quantity of light. Supposing now I use an aperture in the shutter double the length and double the speed, so as to produce an exposure of equal duration, I find I am approaching much nearer the ideal shutter, for I admit as much light as an ideal shutter would admit in $\frac{1}{310}$ second. If, again, I treble the length of opening, keeping up the speed in proportion, I shall admit as much light in $\frac{1}{210}$ second as an ideal shutter would in $\frac{1}{266}$ second; $\frac{1}{266}$ would be the equivalent exposure, and the closer the actual and equivalent exposures approach, the more efficient the shutter.

If wanted for general work, and carried in case of need rather than for a pre-arranged purpose, a range of from about $\frac{1}{8}$ to $\frac{1}{60}$ will be found very useful. If it is intended to take things close and in very rapid motion, from $\frac{1}{200}$ to $\frac{1}{400}$ will be sufficient.

It is better to have a separate shutter for every class of work, because adjustable shutters are complicated and of little use unless the various speeds are known, and even when known they do not continue uniform.

The shutter when in position and fully open must have no part of it visible when the eye is brought to look through the lens from the extreme corner of the plate. This fault is a very common one with shutters fitting on the hood of the lens; in fact, the hood of the lens invariably comes in view of the plate.

The whole field should be exposed simultaneously, or if any part gets more exposure, it should be the part which needs it, viz., the foreground.

It is laid down by the best writers on the subject that as large a proportion as possible of the exposure should be given with the full aperture, and that the period of opening and closing should stand in a small proportion to the period of full aperture. This rule, although absolutely true as to all shutters which work in front of or behind the lens, should not, for reasons which I will explain, be extended to those working between the components. There must be no jarring until the exposure is quite over, and, if possible, such should be altogether avoided; and further, a shutter should be small, not to catch the wind; light, not to strain the lens, mount, and camera front; and simple, in order that it may have little to go out of order, and that if it does, its repair may be within the reach of the ordinary amateur.

Simplicity is the most absolute necessity, but is met with in only one shutter out of a hundred. Shutters, no matter where placed, may conveniently be classed as (1) drop shutters, (2) eyelid shutters, and (3) go-and-return shutters. Drop shutters, in spite of their disadvantage in exposing the sky most when worked in front of the lens, have advantages which recommend them much to practical workers. They are simple, uniform in action, and free from jar until the exposure is over. The opening in the drop must not be round or rectangular, or the edges of the plate will be needlessly robbed of light. The opening should be curved thus:

which causes an evener exposure by depriving the centre of the plate of a little of its light. I always prefer not to insert stops in the lens, but to stop down by closing up the aperture of the drop, which should for the purpose be adjustable. The drop should be liberated so that it shall have fallen some distance before the exposure commences. This gives a faster and more even exposure. A drop shutter placed on the hood exposes the sky more than the foreground; if mounted between the combinations, it exposes both exactly evenly; if behind the lens, it exposes sky least. Behind the lens, therefore, is the best but not the most convenient position. Drop shutters should on no account, unless heavy, be accelerated with a spring, as the kick-back which would follow the release must shake the camera. The speed of the drop may be greatly decreased by turning the shutter on the hood so that it descends an inclined plane, the friction thereof retarding the fall. Drop shutters vary from about $\frac{1}{15}$ to $\frac{1}{60}$ second. A drop shutter with an opening of $2\frac{1}{4}$ inches registers about $\frac{1}{15}$ second, and possesses great efficiency; with an opening of $\frac{1}{4}$ inch it registers about $\frac{1}{60}$ second, and is of very low efficiency.

The Kershaw belongs to this class; it acts with a spring blind, is adjustable and simple, the opening is much longer than the lens aperture, it therefore is probably the most "efficient" shutter made. It varies in rapidity from about $\frac{1}{17}$ to $\frac{1}{60}$. This is probably the most desirable shutter for general use, and one of the very few shutters which have my entire approval. It exposes foreground and sky equally, but is not at all fast enough for very rapid work. To this class also belongs Lancaster Instantograph. It is not rapid, is of very low efficiency, it makes the exposure not through the centre, but to one side of the lens, and is not to be as much recommended as some others for general usefulness.

Eyelid shutters are those which open from and close to the centre. This motion is produced by two slides crossing one another; the openings, meeting in the centre, cause the lens to open and close as the eye does. These shutters are the fastest, both because of the double slide and that when used, as they generally are, in the position of the stop, the aperture may be small. They are, however, generally of low efficiency, and when such, have a faculty of giving far better definition all over the plate than would be attainable with an ideal shutter and with a fixed stop of an intensity equal to the average of the various periods of intensity existing during the exposure with the eyelid shutter in question.

For example, take the exposure given with an Eyelid shutter, having an opening equal to that of the lens *f*/8, and divide the exposure into a number of, say, nine periods. The duration of exposure with each will approximately be—

With intensity	of	*f*/32,	$\frac{2}{9}$	of entire exposure	given.
,,	,,	*f*/23,	$\frac{2}{9}$	,,	,,
,,	,,	*f*/16,	$\frac{2}{9}$	,,	,,
,,	,,	*f*/11·5,	$\frac{2}{9}$	,,	,,
,,	,,	*f*/8,	$\frac{1}{9}$	,,	,,

Now if you give with the same lens and an *f*/13 stop the same duration of exposure you have given with the shutter above mentioned, you will find the efficiency of both about equal; in other words, the average intensity of the constantly varying shutter aperture is equal to that of an aperture of about *f*/13. You would naturally expect that the general definition over the field produced by each would be the same, but will find it not so in practice, but that the shutter will give you a flatness of field and depth equal to an average stop, not of *f*/13, but of about *f*/20. That this result is as I describe is conclusively shown by results, and the explanation I suggest is as follows. The principal object will of course be always in good focus, but the objects further and nearer, or to the extreme edges of the plates, will be in fair focus only so long as the lens is stopped down by the action of the shutter. The moment the lens opens fully, the outlines of the objects situate beyond the plane of focus spread as it were beyond their legitimate limits. Therefore we have the objects impressing themselves upon part of the plate (viz., that within the limits of keen definition) during the entire period of exposure, and the same objects spread beyond (so far as regards the area outside their originally well-defined limits impressing the plate) during only part of the exposure. Now in doing very quick work the exposure is never more than enough, especially at the edges of the plate, and as the entire period of exposure is required to produce a developable image, it follows that it is only the limits which were acting on the plate the full period of exposure which will show up, and the practical effect of this is to improve the marginal definition to an extent greater than would be the result with a fixed stop of average intensity.

An inherent defect of every doublet lens used with a full aperture is that the mount partially cuts off the oblique pencils of light that go to form the margins of the picture. In many cases where the lens only covers the plate in use and no more, the margins receive under such circumstances light through a small part only of the lens. In one case recently I found that whilst the centre of a plate received exposure through an aperture of

$f/8$, the corners only received it through one of $f/18$, consequently the centre got five times more than the corners.

In the same way that full exposure levels the contrast of sunshine and shadow, so also in time-exposures it levels this inequality of illumination; but when the exposures become scant, as in very rapid work, the defect stands prominently out, and anything tending to further aggravate the evil should be avoided. Hence it becomes so important that the shutter shall not cut off any of the marginal pencils.

Eyelid shutters, when of low efficiency, should for these reasons be used only between the components of a doublet lens, and the lens should be able to cover a plate at least one, and better two, sizes larger than that in use; if intended to be used on the hood, the opening must be considerably longer than the diameter of the lens, so that the time during which it is fully open bears a large proportion to that when it is opening and shutting.

I shall not here give any particulars of the speeds of the various shutters I have tried, but at the end of this paper I shall give a list of approximate rapidities.

To the class of shutter I have just spoken of belong Sands and Hunter's, also that of Thury and Amey (sold by Watson's), and Caldwell's (sold by Wray), all opening from the centre of the lens by drawing two superimposed slides in opposite directions. They are of very low efficiency, and, therefore, only available between the components of a doublet. Amey's is almost prohibitive in price and weight. Caldwell's is a new shutter, unquestionably the best *of its kind*. It is light, neat, and fast, and can, like the other two, be adjusted to various speeds. What those speeds are is another question. In a shutter just finished for me by Mr. Caldwell, speed $\frac{1}{700}$, I have omitted the brake for adjusting speed. If there were less complication, and that so much was not sacrificed to neatness, and if more pains were taken to lessen the friction, and more run given to the slides before the exposure begins, these shutters might be greatly improved. The shutter which I arranged and used last season is on exactly the same principle, but is without mechanism of any kind beyond two springs, and its construction is within the reach of any amateur who can make a drop shutter. Messrs. Perken, Son, and Rayment, of Hatton Garden, London, are, with my permission, making this shutter now. It is intended for very rapid work only, and is not adjustable. I worked it last season up to $\frac{1}{300}$, but have no doubt it will be faster with the improvements I have suggested this season. This shutter is made of medium or low efficiency, according as it is intended to be used on the hood or between the combinations. I intend to continue its use this season, and prefer low efficiency, and to work it between the components of my lens.

To this class also belong Watson's Double-Snap, which works in front of the lens, opening from the centre like a pair of scissors; also a shutter sold by Sharp and Hitchmough, of Dale Street, Liverpool, which is simply a Kershaw with a double blind. This shutter is used very successfully by the celebrated worker, Mr. Paul Lange, of Liverpool, and is the most efficient of its class; the details and workmanship are not good, but if properly made it would be very fast, and would probably be the best shutter for detective cameras.

To this class also belong Shew's Eclipse, Wollaston's Diaphragmatic, Newman's.

To the third class—Go-and-return shutters—belong those which possess most advantages for any kind of work, wherein it is desirable to expose the upper part or sky of the picture more than the lower part or foreground.

In these shutters the slide, when released, is drawn up by a spring arrangement, and returns and closes the shutter again. In some forms the return is accelerated by the slide striking a rubber band above. This rebounding is calculated to produce a jar just in the very centre of the period of exposure.

This class of shutter is usually placed on the hood, and this is the only position in which it has the advantage of exposing the sky less than the foreground.

Some of these shutters—such as, for example, the Grimston—belong to this class, but work in the diaphragm slot, where they possess none of the advantages appertaining to their class, but enjoy the disadvantage of preventing the use of a diaphragm, which is generally necessary, and, furthermore, are liable to that peculiar blurring which is produced by many lenses when a stop is accidentally inserted, admitting pencils of light from opposite sides of the aperture, and which blurring is due to the defective correction of the lens.

To this class of rise-and-fall shutters also belong the Phantom, Due-Ratio, the Evolute, the Plunge, Right-about Turn, the Phœnix.

This paper is hardly complete without a word about timing shutters. I need not, however, describe the apparatus which I have used and so far found perfectly satisfactory, as Mr. Stelfox has fully described it on page 90 of the AMATEUR PHOTOGRAPHER, No. 227. I am however, now using a far more delicate and equally simple machine, which Mr. W. J. Wilson, of the Paget Plate Company, has invented, and which, like everything else he puts his hand to, is the best of its kind, but which I must refrain from describing, as it will shortly be shown and placed on the market by Mr. Wilson himself. The apparatus described by Mr. Stelfox is practically accurate, but requires sunshine. Mr. Wilson's is absolutely so, and can be worked by artificial light.

Shutters even of the same make will always vary, and sometimes very much, particularly those with mechanism.

The following is a list of the rapidities shown by certain shutters, which may be of some little use in affording an approximate idea of what may be expected from them :—

	Second.	
Drop Shutter	$\frac{1}{16}$	Aperture, $2\frac{1}{4}$ sec.
" "	$\frac{1}{60}$	" $\frac{1}{4}$ sec.
Newman's	$\frac{1}{13}$	Whole-plate.
The Plunge	$\frac{1}{6}$	Quarter-plate.
" "	$\frac{1}{11}$	" "
Watson's Double Snap	$\frac{1}{20}$	Whole-plate.
Phantom	$\frac{1}{12}$ to $\frac{1}{33}$	" "
" sky	$\frac{1}{100}$	Quarter-plate, double bands.
" foreground	$\frac{1}{40}$	
Cadett's Lightning : sky	$\frac{1}{33}$	Whole-plate.
" " foreground	$\frac{1}{26}$	
Wollaston's Diaphragmatic	$\frac{1}{25}$	Whole-plate.
Robinson and Sons' (go and return) : foreground	$\frac{1}{15}$	Half-plate.
" " sky ...	$\frac{1}{22}$	
Lancaster Instantograph	$\frac{1}{15}$	Half-plate, medium band.
Kershaw	$\frac{1}{17}$ to $\frac{1}{60}$	Whole-plate.
Grimston ... ... up to	$\frac{1}{23}$	Aperture, $1\frac{3}{4}$ ins.
Meldon (as made by Perken) ... "	$\frac{1}{300}$	" $1\frac{1}{4}$ "
Caldwell (as made by Wray) ... "	$\frac{1}{200}$	" " "
Thury and Amey ... ... "	$\frac{1}{300}$	" " "
Mr. P. Lange's	$\frac{1}{77}$	" $1\frac{1}{2}$ "

COMPETITIVE PAPER No. IV.

THE SENSITIVE MEDIUM.

First Prize—L. A. BURROW.

ALL the salts of silver are decomposed by light to a certain extent; but the salts used in gelatino-silver dry-plate emulsions are those known as the silver-haloid compounds, *i.e.*, the chloride, bromide, and iodide. Of these, the bromide and iodide are the only ones used for the negative process, the chloride being used in the preparation of plates for lantern slides, printing-out processes, and transparencies, which are beyond the scope of the present article.

Silver Bromide is formed by the double decomposition of silver nitrate with a soluble bromide, such as potassium or ammonium bromide. It is insoluble in water, soluble in alkaline hyposulphites, cyanides, and ammonia. It becomes of a tawny grey colour on exposure to light.

Silver Iodide is formed in a manner analogous to the bromide, possessing much the same qualities, except that it is insoluble in ammonia. It is of a yellowish colour, turning to a greenish grey on exposure to light, some absorbent of iodine being necessary to make the effects of photo-decomposition visible.

The darkening of these salts by light is accompanied by the liberation of bromine or iodine, as the case may be, a sub-bromide or sub-iodide being formed. The action of light is greatly accelerated by the addition of some bromine or iodine absorbent, which is called a sensitiser. In gelatino-silver dry plates the gelatine itself acts as the sensitiser, although the exact nature of the compounds formed is not known. In a gelatine emulsion the bromide is much more sensitive to light than the iodide, although, by itself, the latter is the more so of the two. In the first place, the sensitising action of gelatine for bromide may be greater than for iodide, or the iodide may not exist in that sensitive molecular state of aggregation which the bromide can maintain in a viscous mass. With iodide used alone in an emulsion, the image is dense, but there is little detail in the shadows and high lights; with the bromide the image is flatter, but full of detail and quicker. Many makers use the bromide alone, but a bromo-iodide emulsion is preferable, as the iodide checks the appearance of fog in development, and gives more latitude in exposure.

Gelatine, which is the vehicle now universally employed for the sensitive salts, is extracted from bones, sinews, cartilage, etc. It liquefies when heated, and when cool becomes a more or less firm gelatinous mass. That used for emulsion purposes must be of the best quality, as much depends upon it. It should not absorb more than ten times, or less than five times, its weight of water. It contributes to the sensitiveness of the silver salts by its great affinity for bromine and iodine.

An emulsion is so called because in it the sensitive salts of silver are emulsified or held in suspension in a state of extremely minute division. It would be impossible in this limited space to give full details of the manufacture of emulsions, and the following description is intended only to give a general idea of the methods of preparing them in small quantities. There may be said to be three methods of preparation, differing only in the manner of ripening or increasing the sensitiveness, viz., by boiling, by digesting at a low temperature, or by treatment with ammonia.

Three hundred and seventy grains of potassium bromide are dissolved in 4½ ozs. of distilled water, and to this solution 100 grains of gelatine are added and dissolved by the gentle application of heat. The remaining operations must be carried on in a dark-room. Four hundred and fifty-eight grains of silver nitrate are dissolved in 10½ ozs. of water, and added little by little with frequent shaking to the bromised gelatine. Finally 30 grains of potassium iodide are dissolved in 3 drms. of water and added to the rest. An insoluble precipitate of silver bromide and iodide is thus formed in emulsion, together with soluble potassium nitrate. At this stage the emulsion should appear of a ruby colour when examined by transmitted light. To ripen or give it the required sensitiveness, it is boiled for about forty minutes, when it becomes extremely sensitive, the actual sensitiveness depending upon the length of time it is boiled. It should now be of a bluish colour when viewed by transmitted light. Five hundred grains of gelatine dissolved in 6 ozs. of water are next added to and thoroughly mixed with the cooked emulsion, the temperature of the two being first brought to the same. The mixed solutions are then poured out into a flat dish, and allowed to set preparatory to washing to remove the excess of potassium bromide and the potassium nitrate. When set, the emulsion is broken up into small pieces, squeezed through a piece of coarse canvas into a dish of distilled water, collected, washed in several changes of water, allowed to drain thoroughly, and finally remelted at as low a temperature as possible. A small quantity of chrome alum is added to render the gelatine partially insoluble, and after filtering through a piece of swansdown calico, or chamois leather, the emulsion is ready for use. The reason for not adding the whole of the gelatine from the first is that there is danger of its being decomposed by heat if alkaline, the risk being greatly diminished by boiling only a small quantity of it.

The second method differs from the first only in the process of ripening. To ripen the emulsion, it is placed over a hot-water bath and digested at a low temperature for ten or twelve hours. It is then sensitive enough for slow plates. If great sensitiveness be required, the operation must be continued for about three days. As the emulsion is not boiled, the whole of the gelatine may be added from the first. This method is much more certain than the preceding one in unskilled hands, the change taking place so slowly that it is under much better control.

The proportions used in the ammonia process may be the same as for the preceding processes, but before adding the silver nitrate to the bromised gelatine, sufficient strong ammonia is added to redissolve the precipitate of silver oxide first formed. The emulsion is kept at a sufficient temperature to keep it from setting for half an hour; the operations of washing, etc., are then carried on as before. If the emulsion is required to be kept and not used at once, it must be placed in alcohol, and can then be kept for a considerable time.

The quantity of potassium bromide in an emulsion is so adjusted as to leave no excess of silver nitrate, as colloidal substances, such as gelatine, combine with the silver nitrate, forming a gelatinal nitrate from which the silver is reduced on heating. If sufficient potassium bromide is not added, the whole of this gelatinal nitrate is not decomposed, and fog is caused on the plate. The amount of gelatine to the silver salts should be as small as possible, as a large amount would entail a thicker film, which is more liable to frill and takes longer to dry. On the other hand, the quantity of gelatine must not be too small, or a granular film will be the result, which is very liable to leave the plate.

The increased sensitiveness of an emulsion by boiling is caused by a gradual change of molecular aggregation in the silver compound, the increase of sensitiveness being accompanied by an increase in size of the particles of silver bromide, thus exposing a larger surface of the sensitive salt to the action of light. If the ripening is continued too long, the particles continue to grow, and a chemical reaction sets in, causing a deposition of the bromide. In the ammonia process the solubility of silver bromide in ammonia is probably the immediate cause, some of the dissolved bromide being precipitated upon the particles held in suspension. The change in the optical qualities of the emulsion is a purely physical one. Newly precipitated silver bromide allows the red rays to pass through, but as the particles become larger the red rays are checked, and the colour becomes a bluish grey in the ripened emulsion.

Coating the Plate.—The plates must be first thoroughly cleansed from dirt and grease, polished, and the rough edges taken off. They are then warmed to bring them to about the same temperature as the re-melted emulsion, a sufficient quantity of which is poured on to the plate, and caused to flow evenly over the surface, the excess being poured off from one corner. The coated plate is then laid on a level slab of glass or slate, and when set is placed in a rack, and removed to a drying cupboard. This cupboard is so arranged that it can be kept at an even temperature, and a current of warm, dry air constantly circulated through it. When large quantities of plates have to be dealt with, a special room, well ventilated and perfectly light-tight, is set aside for the purpose. The plates should remain in this for about twenty-four hours, to make sure of their being perfectly dry. The coating of plates by hand is now almost entirely superseded in dry-plate manufactories by the use of machines which have been devised for the purpose. There are several varieties of plate-coating machines, a full description of which would be impossible in this limited space; but the following is the principle of Edwards' machine, which is the one mostly in use. A glass roller, with a perfectly smooth and accurate surface, revolves in a trough containing warm emulsion. A scraper with a straight edge removes the film of emulsion from the roller, so that it falls down the outside of the scraper, leaving the roller beneath the straight edge perfectly clean. An endless row of glass plates is caused to travel beneath the scraper, receiving the film of emulsion in a kind of soft endless band of uniform thickness. The travelling band, carrying the coated plates, passes over a table or slab artificially cooled by cold water or ice, so that the emulsion sets before it reaches the delivery end of the machine. By means of this machine as many as 1,200 whole-plates can be coated per hour. For the smaller sizes of plates it is usual to coat the glass in large sheets, and when dry, to cut these up into the required sizes. The glass is cut with a diamond, in special cutting frames having guides to cut the plates to the exact size and shape required. The preferable plan adopted by some makers is to cut the glass to the required sizes before coating, as otherwise small splinters of glass are apt to become imbedded in the film in cutting.

Packing.—The smaller sizes of plates are best packed by folding a continuous strip of tissue paper between each, the larger sizes packed face to face with a strip of cardboard between each pair. Commercially the plates are packed in boxes containing one dozen, one of the most convenient methods being that used for the Pall Mall plates. A strip of non-actinic paper is first placed in the bottom of the cardboard box, with ends projecting long enough to cover over the plates when full. The plates are then placed in the box with a continuous strip of tissue paper folded between each. This box is wrapped in black paper, and slipped into a cardboard case, which again fits into an outer case, thus securing complete security from light, and considerable immunity from breakage.

Films.—From the earliest days of photography, efforts have been made to provide some fitting substitute for glass as a support for the sensitive film. Glass is open to many objections on account of its bulk, weight, liability to be broken, etc. To tourists especially it is a matter of great importance to get rid of the weight of glass plates, a great number of sheets of paper or other flexible films being carried with the greatest of ease whilst the same number of plates would be a heavy burden. There are other advantages in the use of films—their suitability for carbon printing, as they can be printed from both sides, and their great freedom from halation. Amongst the many films in use, Eastman's American stripping films take the foremost place. A paper support is coated with a layer of plain soluble gelatine, on which again is a film of insoluble gelatino-silver emulsion. The exposure, development, fixing, and washing are proceeded with in the ordinary manner, after which the film is laid face down on a collodionized sheet of glass and the paper support removed by warm water, which dissolves the layer of soluble gelatine, leaving the insoluble film on the glass. A prepared sheet of insoluble gelatine, cal'ed a stripping film, is then squeegeed on to the film, and when dry, the whole is stripped from the glass, forming a very clear and transparent negative.

In the Vergara films, now extensively used, the flexible support consists of a mixture of gelatine, glycerine, alcohol, water, and bichromate of potash, exposed to light to render it insoluble. These films require no stripping, the manipulation being the same as for glass plates. A new film, Carbutt's patent, is now being introduced from America, in which the support consists of a very thin, transparent sheet of celluloid. It appears to answer very satisfactorily, but at present its high price is against it.

The following are some of the properties a good plate should possess:—The support should preferably consist of a thin flexible film, require no stripping, and the same amount of manipulation only as a dry plate. The sensitive film should be rich in silver, in order to give plenty of density in development, and it should not be too thin, as such are especially subject to halation. The emulsion should be prepared with iodide as well as bromide, giving more contrast, less liability to fog, and to some degree checking halation. Concerning rapidity, for portraiture and objects in motion a very rapid plate is necessary, but for ordinary landscape and architectural work a slow plate possesses many advantages. In the first place, much more latitude is allowable in exposure, for whereas with a rapid plate two or three seconds difference in exposure might spoil the negative, five or ten seconds will not spoil a slow plate. Rapid plates can of course be given a longer exposure by using a small stop in the lens, but it is at the expense of a certain amount of brilliancy. A slow plate gives great contrast and a brilliant image, while a rapid plate gives a soft effect with a certain amount of flatness. A slow plate will also stand much rougher treatment in development.

The original standard for the comparison of the sensitiveness of gelatine dry-plates was a wet collodion plate, and the plates were distinguished as being so many times more sensitive than the standard plate. The wet collodion plate is not a good standard, as its relative sensitiveness compared with that of a dry-plate varies with the amount of light. The sensitiveness of plates is now determined by a sensitometer, generally Warnerke's, and the plates marked with the number found by it.

The exact nature of the action of light on the silver salts has not yet been fully determined. Taking the chloride, for example; it is known that its darkening under the action of light is accompanied by the liberation of chlorine. It is also found that the presence of oxygen is essential to the darkening of the chloride. As the latent image is believed to consist of the same material as the darkened haloid, it probably consists of a sub-oxy-chloride combined with unaltered haloid. Carey-Lea has produced by chemical reactions what is supposed to be the same compound as that of which the latent image is formed. The latent image can also be produced by mechanical pressure. The action of light on the sensitive film is superficial, the actual amount of haloid decomposed by the picture varying with the actinic quality of the light. In good gelatine plates the latent image can be preserved for two years before development, but it will eventually disappear.

When glass-plates are used on interiors or bright landscapes, it is advisable, in order to prevent halation as far as possible, to coat the backs of them with some opaque substance. Many forms of backing are in use, one of the most satisfactory being a backing of black or red pigment, mixed into a paste with gum water and glycerine, which can easily be washed off before development.

When travelling I have found it most convenient with quarter-plates to carry them in the boxes as supplied by the makers, and after exposure, to return them to the box in the same order that they were exposed. If a changing-bag is not carried, the plates can easily be changed under the bed-clothes at night, very little practice being necessary to empty and refill the slides in the dark.

THE SENSITIVE MEDIUM.

Second Prize—W. P. H. FOSTER.

There are two kinds of gelatine used for emulsion making—the hard and soft, known as Nelson's No. 1 (soft) and X opaque (harder), Coignet's gold medal (hard), and Heinrich's (hard), etc. Gelatine is frequently greasy, particularly the flat flakes, from being handled with dirty fingers, and from, I believe, a fault in the manufacture of some kinds; this difficulty may be overcome by precipitation, or by wiping the flakes with cotton wool and spirits of wine, without which it is liable to produce pits or spots.

The Salts of Silver.

Commercial Nitrate of Silver is sufficiently pure for emulsion making, although some prefer the triple crystallised. Of the bromides ammonium bromide is most generally used; a few workers use the potassium salt. The former is thought to confer greater sensitiveness, and the resulting ammonium nitrate is preferable to the potassium nitrate in cooking an emulsion. Silver nitrate combines with the bromide as under:—

Weight of ammonium bromide to convert 1 gr. silver nitrate, ·576 gr.

Weight of potassium bromide to convert 1 gr. silver nitrate, ·700 gr.

Weight of silver nitrate to convert 1 gr. ammonium bromide, 1·734 gr.

Weight of silver nitrate to convert 1 gr. potassium bromide, 1·427 gr.

Iodide of Potassium is more generally used than the ammonium salt, on account of its greater stability. From the small quantity used in an emulsion, the resulting potassium nitrate is of little consequence. Iodide of silver alone is not amenable to the usual dry-plate developers, but iodide of silver combined with gelatino bromide is believed to be, to a certain extent, developable, or at least confers such qualities upon the bromide that the development is cleaner, more vigorous, and also a better light may be used while developing.

Weight of silver nitrate to convert 1 gr. iodide of potassium, 1·023 gr.

Weight of iodide of potassium to convert 1 gr. silver nitrate, ·977 gr.

A soluble chloride is used in small quantities with bromide emulsion, and also for chloride emulsion for lantern plates, or paper for printing by development. Chloride of silver, like iodide of silver, requires free nitrate of silver, to attain its maximum sensitiveness; as this is not possible in gelatine, on account of the staining of the film by the silver nitrate, recourse is had to development to obtain the same result. Chloride of ammonium combines as follows:—

Weight of nitrate of silver to convert 1 gr. of ammonium chloride, 3·177 gr.

Weight of ammonium chloride to convert 1 gr. of silver nitrate, ·315 gr.

By the addition of a solution of the silver haloid to a solution of the soluble haloid, the following reaction takes place:—

Nit. Sil.	amm. bromide ..	amm. nitrate ..	silver bromide
	potass. bromide ..	potass. „ ..	„ „
	iodide potass. ..	„ „ ..	„ iodide
	amm. chloride ..	ammon. „ ..	„ chloride

The bromides, iodides, etc., of the heavier metals are not so suitable for gelatine emulsions, as their bases act, chemically, prejudicially, and should therefore be avoided.

A pure bromide plate correctly exposed in a well-lighted studio gives great softness and gradation, but very little latitude in exposure. The judicious combination of iodide and chloride confers valuable properties, and allows much greater latitude in exposure, which is a great acquisition when the light is uncertain.

Making an Emulsion.

The simplest form of emulsion is that published by Kennett:—
Weigh out (with clean scale pans) and place on clean writing paper—

A.

Gelatine, Nelson's No. 1	20 grs.
Coignet's or Heinrich's	20 „
Potassium bromide	30 „
Water	1 oz.

B.

Silver nitrate	40 grs.
Water	½ oz.

Place the bromide in the water (1 oz.) in a glass beaker or other convenient appliance that will stand boiling water. When dissolved, add the gelatine, and allow to stand some time until the bromised water is taken mostly up and the gelatine swollen, then heat by placing in warm water (100° F.) to dissolve the gelatine. The silver solution also should be in a suitable phial, and heated to same temperature, when it may be added in a thin stream, constantly stirring the bromised gelatine with a silver fork, spoon, spatula, or glass rod, while the whole of the silver solution is added; the emulsion being well stirred, it may rest until set. Afterwards it may be washed and further treated (See Washing Emulsions.) Should greater rapidity be desired, this emulsion may be stewed for several days. (See next paragraph.) As stated before, the ammonium salt would be preferable for stewing; its equivalent weight would be ·25 gr.

Stewing.—Another method is to put the bromide and water into a suitable wide-mouthed bottle, and when dissolved, add the gelatine, proceeding as before up to the solution of the gelatine, when the nitrate of silver is added in crystals, and vigorously shaken until dissolved, and a fine emulsion results; this may be either boiled or at once poured out to set. Note, in boiling an emulsion, it is best to use only a small proportion of gelatine, viz., 5 or 10 grs. to the ounce, adding the remainder when boiled and cooled to about 90 or 100° F. If the bulk of the gelatine is added at first, it is better not to raise the temperature higher than 90 or 100° F. at most. The emulsion may be stewed for several days if kept between 70 and 90° F., testing from day to day as to quality.

Ammonio-Nitrate Method.—Proceed as first example, adding liquid ammonia to the silver nitrate until the precipitate first thrown down is redissolved, then add to the bromised gelatine, constantly stirring or shaking. Should the minimum of gelatine be used, it may be boiled, or it may be stewed, or even allowed to ripen in the solid state. Note, ammonia quickly ripens an emulsion, and also destroys the setting power of the gelatine, so that it is better not to keep it long, especially in warm weather, unless with a minimum of gelatine.

There is the method of using a spray producer to obtain extreme fineness of quality. This is made by fitting a cork in a convenient-sized test-tube, bending and drawing ¼ in. glass tubes to a suitable shape, which may be easily done over an ordinary gas flame, boring the cork to fit the tubes tightly; then when the fluid nearly reaches the lower end of the short tube, by blowing down same the fluid is forced up and through the bent tube and from its fine end in the form of spray, if the aperture is fine, which may be made so by a fine file (first closing the tube when drawing it through the gas). A few strokes make an extremely small aperture, which will produce a very fine spray.

Note.—It must be always understood that the mixing of the before-mentioned emulsions take place only in a safe ruby light. Gas, fire, or any actinic light should be avoided, as it is fatal to successful results. Sometimes a stone or earthen bottle may be used, care being taken that its cover or cork does not come out while exposed to actinic light. An emulsion may be made in the presence of bichromate of potassium. Also an emulsion giving fog from the access of light may be restored by soaking (see Washing) in a 5 or 10 gr. solution of this salt, for a few minutes, and well washing afterwards, until all trace of colour is gone from the washing water.

Testing Emulsions.

After mixing an emulsion, a few spots should be placed and spread upon a piece of glass taken to a good light (gas or candle) and examined, first by a magnifier of three or four inch power, for granularity. If this is absent and the flame of a candle or gas appear of a ruby colour when viewed through it, it is (as far as mixing goes) correctly made. This examination should be continued at intervals, in the stewing process every day at least, for two or three days, then oftener. In the boiling, every five or ten minutes, according to the time boiled. The ruby colour before-mentioned passes to orange, from thence to steel-grey, and finally blue-grey; this is the height of the emulsion worker's ambition, provided he can keep the granularity down as much as possible; great care is required to obtain this very desirable change, and it is very soon lost or passed without great care, a hopeless granularity being set up that no amount of doctoring will rectify. If the small quantity of gelatine is used as in the boiling method, it is as well to have a little gelatine ready dissolved, so that your tests may be pursued to the best advantage, by mixing a spot or two with the emulsion to be tested.

Washing Emulsion.

When the emulsion has set well and quite hard, it may be broken up, and cold water poured upon it. A piece of canvas scrim (a coarse Berlin wool canvas) of suitable size placed on the bottom of a basin or other contrivance, scrape the emulsion on to it, and gather the corners together; filling the basin with cold water, proceed to squeeze the emulsion through the meshes of the canvas; when all is through, the basin may be covered up for twenty minutes. The water may then be changed as follows: Place a piece of muslin over another basin, of similar size, attach with string or other method to form a drainer, proceed to pour the emulsion on top, the water going through; this may be allowed to drain some minutes, providing the light is safe, when it may be gathered up in the muslin as in the canvas, and suspended in a jug of water (changing the water frequently) for an hour or two. When the washing is considered complete, a drop or two may be taken *from the emulsion* and evaporated by heat on a piece of glass, or platinum foil. Should there be any crystallisation, the washing must be continued; if not, the emulsion may be dissolved and filtered. Some gelatines absorb more water than others, increasing in bulk; if this is the case it is well to soak the threads of emulsion in good methylated alcohol (free from resin) for a short time, when strained off it may be re-melted and filtered.

Another method is to pour the emulsion (while fluid, but cool) into some convenient jar or bottle containing double the quantity of alcohol or good methylated spirit to the water originally used in the emulsion, stirring it round. It will soon settle down in a mass, and must now be washed; test the droppings of washing water, and redissolve, making up to its original bulk. A little alcohol added in all cases (one-eighth ounce to each ounce) is advisable, as it preserves the gelatine and assists it to flow.

An emulsion made with 1 or ½ grain of gelatine to the ounce of water used may be boiled, allowed to cool, standing until the bromide of silver is settled down, pour off the liquor, add fresh water, let stand and settle, and repeat; about three or four washings may be sufficient; the gelatine being previously soaking in water, may now be added, heat applied, and made up to its proper bulk.

Mr. W. K. Burton gives the amount of silver nitrate required to cover the various plates with the quantity of emulsion required as follows:

Plate.	Emulsion.	Approximate Silver required for each Plate.
¼	80 minims.	2½ grs.
⅓	¼ oz.	3½ ,,
½	⅓ ,,	5 ,,
1/1	⅔ ,,	10 ,,

Gelatine is usually from 15, 20, 25, and 30 grains to the ounce in the finished emulsion, the medium number (25 gr.) being that most used.

Filtering the Emulsion.

When washed, redissolved, and alcohol added—being, of course, made up to its original bulk—it is filtered while still warm through fine cambric, lawn, or muslin, once or twice thick, chamois leather, also, when damped after carefully washing in cold water and a little ammonia or soda, makes a good filtering medium. The tube of the funnel used should be long to reach nearly to the bottom of the bottle, so as to avoid bubbles being formed; the emulsion being kept warm is now ready for coating.

Coating Plates.

A good plan is to have two zinc or tin boxes made about 3 ins, deep, with an inlet at the side and a convenient size in proportion to the plates coated. Mine are 10 by 10 by 3 ins.; on each I have a slab of slate ground level. One is filled with hot water, adjust the slate truly level, the other is placed close enough to slide a plate from the first, and is filled with cold water. The glass is cleaned and stacked ready for use. I take a sheet (whole-plate), place upon the slab over the hot water, I proceed to carefully and lightly (to prevent making a dust) to dust its upper surface, then I take from 6 to 7 drachms of emulsion (best measured in a glass or plated ladle made to size). This is carefully poured on the centre of the plate and quickly spread with a glass rod (bent L fashion) equally to each side. The glass now being slightly warm assists this, but should it be cold, I lightly breathe upon it; this assists the spread of emulsion. When evenly coated I carefully slide the plate on to the slab over the cold tank, the emulsion sets firmly by the time another plate is ready to go on to its place. The first plate when set may be removed to a convenient table, shelf, or the drying cupboard, and the process repeated.

Paper may be coated by rolling up and allowing it to unroll on the surface of the emulsion, suitably placed in the edge angle of a deep dish, and kept warm the while. As each part of the paper is coated, it is gently unrolled and raised from the solution, bringing a fresh part on to the emulsion. Paper may also be coated by using a clean hog-hair brush. If the paper is damped by drawing its surface over warm water, or wetting thoroughly not to get soft, it may be squeegeed on to a sheet of glass, and the emulsion readily spread by means of a brush. Paper, unless squeegeed to glass, should be hung up to dry, of course in absolute darkness, or as nearly so as possible; a prolonged exposure to the ruby ray is quite sufficient to spoil any bromide paper.

The plates and paper are best dried in closets or cupboards specially made with convenient racks for plates, etc., a means of maintaining a regular heat, with unrestricted ventilation, and (equally important) light-tight, with perfect freedom from gas or other noxious fumes. Chloride of calcium is an excellent assistant to the drying of plates, etc. A little placed on tins in the dark cupboard may be removed frequently and dried in the oven, being replaced either warm or cool, as necessary.

In cutting plates it is advisable to have a gauge made as a frame, with a soft flannel bed. Notches are provided so that you may place the rule exactly in its place without much light. I use whole-plates, cutting them twice to use as quarters.

Packing plates I find most convenient in the boxes now supplied by makers. Bank post, or other good paper, cut in strips little less than the plates in width, placing between the face of two, and then another two, finally wrapping the four in brown paper, and then in boxes of one dozen, is the most convenient plan I know.

Glass as a support needs to be thin, flat, and of an even, clear surface, conditions seldom obtained. Flatted crown is a good substitute for patent plate, where price is an object. Any good paper may be used, although very thin. I have successfully used bank post for small negative work, and what is known as Whatman's hot-pressed, or note. For enlargements Rives or Saxe may be used when we can obtain it plain.

The gelatine support is made by cleaning a plate of glass, and dusting same with French chalk. It is collodionised with plain collodion, accurately levelled, a solution of gelatine is poured on and allowed to set, then this is coated with emulsion, and when dry stripped and cut to suitable sizes the first coat of plain gelatine should have chrome alum added.

A good plate should appear an uniform dead matt surface without any appearance of granularity, absence of any lumps, scratches, or other marks, the emulsion being equally distributed all over, and as free from emulsion marks on the back as possible. The colour that plates present varies; some appear greenish and others a creamy grey.

Rapid Plates

are very useful for such subjects that will not admit of a long exposure. I prefer to use a medium or slow plate where possible. The films are not quite so rapid as the fastest plates, but for landscape or average work their excellence and portability go much to recommend them to the notice of out-door workers.

Theory of the Action of Light.

I have an idea that the action of light is primarily, electrical; secondarily, a chemical result takes place. The reason of this opinion is that light has a very powerful action on most organic bodies; this, I believe, is greatly due to electricity.

Packing Plates.

Parcels of plates are most conveniently packed by distributing them through luggage, such as portmanteaus or other packages; the addition of clothing, etc., helps to save them from damage. If a quantity are taken, and of a large size, a suitable box to pack them in with a good lining of straw or other packing I have found best.

To Precipitate Gelatine.

Weigh a suitable quantity, soak and melt without using more water than the gelatine has absorbed, pour this slowly in a fine stream into good methylated alcohol (free from resin); the mass may be washed when the alcohol is poured off, and remelted.

THE SENSITIVE MEDIUM.

Third Prize—J. A. RANDALL.

VARIOUS substances undergo a change on exposure to light. This may be a visible change, as the darkening of silver chloride, or it may be an invisible one, but capable of being made manifest by suitable means, as in the case of the latent image of a photographic plate. The nature of this latent or photographic image has given rise to much discussion. Several theories have been put forward to explain its formation. The most prominent of these are the chemical and molecular theories. The supporters of the first maintain that the latent image is formed by the light starting a chemical change, and that a definite chemical compound is the result. Those who uphold the second theory say that it is merely a molecular change—the arrangement of the constituent atoms is only modified, and no complete separation takes place. In each case the developer discriminates between the altered molecules and the remainder of the film. The chemical theory is certainly supported by more experimental evidence than is the molecular theory, and consequently is now generally accepted as correct. Having decided that the latent image is the result of a chemical change, a more difficult problem is to determine its exact chemical composition. Abney has experimented in this direction, and arrived at the conclusion that the following action takes place on exposing silver bromide, chloride, and iodide to light:

$$Ag_2Br_2 = Ag_2Br + Br.$$

Here silver bromide splits up into silver sub-bromide and bromine. With silver chloride or iodide the same action will occur, chlorine and iodine being liberated.

The sensitive salts in general use by photographers for forming gelatine emulsions are the bromide, chloride, and iodide of silver. The most important of these is the bromide of silver, the other two being added in small quantities to confer some advantage which, if used alone, the bromide would not possess. The silver bromide being the chief salt employed, it is essential to understand its properties and behaviour. It was carefully examined in 1874 by the Belgian chemist, Stas, and fully described by him. Stas claimed six varieties of silver bromide, the principal of which to the photographer are the powdery bromide and the granular bromide. The powdery silver bromide is the orange, and the granular is the grey-blue kind. The orange bromide is produced on mixing, with certain precautions, a soluble bromide, silver nitrate, and gelatine. On boiling or heating this mixture the orange bromide is changed, and becomes converted into the grey-blue silver bromide. The orange bromide is not so sensitive to light as is the granular bromide. With gelatine, granular bromide of silver is the most sensitive substance yet known for receiving a latent image. Their sensitiveness to colour is also different. Abney states that the orange modification is sensitive to the ultra-violet, the violet, and blue rays, and a little in the green; the grey-blue is sensitive to the same rays, and also in a slight degree to the yellow and red rays. The highest sensitiveness will be reached with granular bromide of silver, containing a trace of the orange bromide. The orange bromide, if present in any quantity, will reduce the sensitiveness.

Silver iodide is very insensitive to light when used alone, but combined with the bromide its action is very beneficial. In the first place, it reduces the sensitiveness of the granular bromide to yellow and red light, and for this reason allows a comfortable light for working in the dark-room. Secondly, it renders the film more opaque, and in this way mitigates the evil of halation. Thirdly, greater latitude of exposure is admissable with a plate containing iodide; and lastly, such plates will not be so liable to fog, whence it follows that clearer and brighter negatives will be obtained. The sensitiveness of the granular bromide by the addition of iodide will be reduced only to the yellow and red rays.

Chloride of silver is not extensively used for negative emulsions; it is said to add to the density of the developed image, and to slightly increase the sensitiveness of the silver bromide.

Silver bromide, chloride, and iodide will not readily change on exposure to light, unless there be present some halogen absorbent to take up the bromine, chlorine, or iodine given off. In the wet-collodion process silver nitrate is the absorbent; in the gelatine process the gelatine serves this purpose. Gelatine also gives apparent sensitiveness to silver bromide, by acting as a physical restrainer to development. Bromide of silver does not show such great sensitiveness when emulsified in collodion, simply because so powerful a developer cannot be used. The gelatine employed in preparing emulsions to exert these favourable qualities must be as pure as can be obtained. Too much care cannot be given to the quality and purity of the gelatine. With a good gelatine no great difficulty should be encountered in making an emulsion; with a faulty gelatine it is impossible to get a good emulsion. The most ready way to test a sample of gelatine is to make a trial emulsion, coat, expose, and develop a plate, and note the result.

Before preparing an emulsion it must be decided whether it is to give rapid or slow plates. The difficulty of making a good emulsion increases as means are taken to gain rapidity; whereas to prepare a slow emulsion is a certain and comparatively easy matter. The film of a plate coated with a slow emulsion is of an orange colour, and much denser than the film of a quick plate; for this reason halation is not so likely to impair the quality of the finished negative. With a slow plate a degree of richness can be obtained that is not so often seen in a rapid plate. There is a certainty connected with slow plates, and an amount of comfort in working, which cannot be equalled with rapid plates. They can be developed in a light which adds considerably to this comfort and certainty of result; the plates being more manageable, whilst developing the latitude of exposure is much greater. For fleeting effects in landscapes, instantaneous views, and moving subjects, a rapid plate is, of course, necessary, but when it is not a matter of time in exposure, no advantage can be gained by using an extra rapid plate.

Many methods have been introduced for preparing gelatine emulsions, but they nearly all come under one or the other of the following types:—(1) precipitation process, (2) boiling or acid process, (3) ammonia or alkaline process. The first of these will give only slow plates; the second and third, rapid plates. The second process is most used in England, and the third on the Continent. A general outline of the three methods can be stated as follows:—(1) Preparing solutions of the soluble salts, (2) dissolving the gelatine, (3) preparing the emulsion with a portion of the gelatine, (4) increasing the sensitiveness of the emulsion by heat or other means, (5) adding the full quantity of gelatine, (6) setting of the emulsion, (7) washing the emulsion, (8) draining the emulsion, (9) preparing glass plates, (10) coating the plates, (11) drying the plates, (12) packing the plates. With a precipitation method, No. 4 of these operations is omitted. The following is a description of a process for preparing slow plates by a precipitation method. It was given by Burton, and is a most simple process. The first operation is to prepare as follows:—(A) Nitrate of silver, 200 grs.; distilled water, 3 ozs. (B) bromide of potassium, 160 grs.; iodide of potassium, 10 grs.; Nelson's No. 1 gelatine, 40 grs.; hydrochloric acid, $2\frac{1}{2}$ minims; water, 3 ozs. (C) hard gelatine, 150 grs. (D) hard gelatine, 150 grs. The gelatine of (B) and the two portions (C) and (D) are placed in separate quantities of water and allowed to swell. (A) with (B) and its 40 grs. of swelled gelatine are then heated in the dark-room in separate vessels to 120 degs. F. (A) is next slowly poured into (B), stirring rapidly with a glass rod at the same time. The emulsion thus formed must be left for ten minutes, but stirred at short intervals. Whilst it is standing, the gelatine (C) is taken and wrapped in a cloth, and by twisting the cloth, as much water as possible squeezed from the gelatine. After the ten minutes have elapsed the emulsion is poured upon this gelatine, and heat applied to thoroughly incorporate the two. The emulsion should not be stirred for two minutes previous to doing this. It is now placed on one side and allowed to set into a stiff jelly. When set, the next operation is to wash the emulsion, to remove certain soluble salts. In warm weather the emulsion may set with difficulty; in this case the jar containing it should be stood in water, and in the water several pieces of ice floated. The washing is readily accomplished by placing the stiff emulsion into a piece of coarse canvas or mosquito netting, and then, by wringing this forcing it through the meshes into perfectly clean water. The threads of emulsion are collected, and the operation can be repeated, using abundance of fresh water. When the emulsion is completely washed, all water must be drained from it. This draining will take about two hours. After this interval the gelatine (D) is separated from all superfluous water and added to the emulsion. The whole is next reduced to the liquid state, and filtered through cotton-wool. When one half-ounce of pure alcohol has been added, plates can be coated with it. The above quantity of emulsion will coat a dozen 10 by 8 plates.

Plates prepared by the preceding method will be slow, but of excellent quality and easy to manipulate. For a method to give rapid plates, every step given in the outline must be taken. Abney's process is a good type of the boiling or acid process, and is as follows:—First weigh out on clean paper: (1) potassium iodide, 5 grs.; (2) potassium bromide, 135 grs.; (3) Nelson's No. 1 photographic gelatine, 30 grs.; (4) silver nitrate, 175 grs.; (5) Nelson's No. 1 gelatine and Heinrich's (equal parts), 240 grs. No. 1 is dissolved in 1 drm. of water. No. 2 is dissolved in 1½ ozs. of water, 1 drop of hydrochloric acid added. No. 3 is rinsed, and allowed to swell for ten minutes in 1 oz. of water. No. 4 is dissolved in ½ oz. distilled water. No. 5 is allowed to swell in 2 ozs. of water. The foregoing operations can be done in ordinary light. In the dark-room, No. 4 is heated on a water bath to about 120 degs. F., and No. 3 is added to it. They are then well stirred, and shaken in a bottle to secure a perfect mixture. Next add to this three-quarters of the solution No. 2, little by little, shaking well after each addition; No. 1 is then added to the remaining quarter of the solution No. 2. This fresh mixture is added to the bulk in the same manner as before. The emulsion is now mixed, and, if a success, will appear of a ruby tint, when a thin film is viewed by gas light. Should it present a blue or grey colour, no increased sensitiveness will be gained by boiling. When the emulsion is of an orange or ruby tint, the next operation is to increase the sensitiveness by boiling.

This can be carried out by placing the jar containing the emulsion into a saucepan of water, and then applying heat to boil the water. The boiling must continue for a period of forty minutes, and the emulsion should be shaken every ten minutes. The best plan is to watch the emulsion, and when it assumes the grey or violet tint, if a thin film be viewed by transmitted light, to stop the boiling. During the boiling No. 5 is dissolved by means of heat. No. 5 and the emulsion are then cooled down to between 60 and 80 degs. F., and next added together and thoroughly mixed. The emulsion is next poured into a flat dish and left to cool. It has then to be washed; this can be done by the method already given, or it may be accomplished in the following manner: After the emulsion is boiled allow it to cool almost to setting, and next pour it into a beaker or pot. Now add to the emulsion methylated spirit, stirring briskly at the same time. This treatment will precipitate the emulsion, leaving the soluble salts in the liquid. The liquid is poured off, and the precipitated mass rinsed with fresh spirit. Remove this spirit and break up the emulsion into small pieces, and place it in water to swell. Change the water a few times, and finally remelt the emulsion.

The third method of mixing emulsions is the ammonia process. Dr. Eder's method of procedure is as follows:—

Solution No. 1: Potassium bromide, 370 grs.; gelatine, 520 to 700 grs.; water, 10½ ozs. This can be dissolved as in the second method, and raised to a temperature of 95 degs. to 105 degs. Fahr. Solution No. 2: Nitrate of silver, 460 grs.; water, 10½ ozs. Strong liquor ammonia is next gradually added to No. 2 till a precipitate, which will be formed, is just re-dissolved. In the dark-room No. 2 is added, drop by drop, to No. 1, with constant shaking and stirring. The vessel which contained the ammonio-nitrate of silver is rinsed out with 1½ ozs. of water, and this solution added to the emulsion. The emulsion is now placed in the water-bath, and digested at a temperature of 95 degs. Fahr. from a quarter to half an hour. It is then allowed to cool down to 75 degs. Fahr., but no lower. The temperature at which the emulsion is digested should never exceed 105 degs. Fahr. The emulsion can then be washed by squeezing through canvas in the usual manner, and, after draining, re-dissolving, and filtering, it will be ready for coating the plates.

The plates to be coated are first cleaned with nitric acid, then washed and treated with caustic potash in a solution of methylated spirit, again washed under the tap, rinsed with distilled water, and stood in a rack to dry. Plates should not be polished. To coat the plates with emulsion, a perfectly smooth surface, such as a thick glass plate or slate slab, must be procured; this is levelled by means of wedges and a spirit level. Upon this level surface the plate to be coated is laid, and on the centre of it a small quantity of the emulsion is poured, guiding it to the edges and over the whole surface of the plate with a clean glass rod. When quite cool and set, the coated plate is removed to the drying place. Another way of coating plates is to cover them as if with collodion or varnish, and to place them on the level shelf to set

Plates prepared by the first of the three methods given can be left to dry spontaneously, if the weather be warm and dry. With rapid plates it is usual to employ some kind of drying cupboard. In these a constant supply of warm dry air must be maintained until the plates are dry, which will be from six to twelve hours. Another plan is to soak the plates when thoroughly set in methylated spirit, free from resinous matter, for ten minutes; plates so treated will dry in an hour.

When perfectly dry, the plates must be packed away in places free from damp and light. A good and simple method is to put them face to face without the intervention of any substance, and then to wrap each dozen or half-dozen in orange paper and tinfoil, and to pack in a box with strong corners. Plates can also be packed in grooved boxes, and this is the best method when bulkiness is not an important consideration. For plates to occupy the smallest possible space, and yet to keep each one separate, small slips of cardboard about ½ in. long and ¼ in. wide can be attached to the corners of each plate; in this case they must be packed in non-yielding boxes. To pack plates for travelling, tin or zinc boxes should be obtained of the same size inside as the cardboard boxes containing the plates are on the outside. The plates are placed in these tin or zinc cases, and round the juncture of lid and box should be pasted strips of black calico either by means of an india-rubber solution or a mixture of glue and bichromate of potash.

Any one of the preceding emulsions can be applied to paper or other flexible support. Prints from paper negatives are not always satisfactory, they generally lack brilliancy or show a slight amount of grain. For negative processes gelatine or other transparent support will give the best results. The negative can be prepared upon paper, and transferred from that to a gelatine film to print from. Or an insoluble gelatine film can be supported upon a talced glass, and the emulsion flowed over this, and when dry the whole stripped from the glass. By careful manipulation prints can be obtained from film negatives in every way as good as those from glass supports. To be successful with films it is essential to have every chemical employed as pure as possible, and to keep the films free from dirt, moisture, or other injurious substance. Films seem most susceptible to such influences, and if no extra precautions be taken, stains, spots and markings are sure to occur.

COMPETITIVE PAPER No. V.

EXPOSURE.

First Prize—REV. T. PERKINS, M.A.

If a portion of a sensitive film be exposed to a weak light for a short period, and another portion of the film to the same light for a longer period, or if one of the portions be exposed to a weak light and the other to a stronger light for the same period, and the plate be then developed, it will be found that that portion of the plate which has been most acted on by light will begin to darken first, and if when it has attained any desired density the development be stopped, and the plate be fixed, there will be a perceptible difference between the densities of the two portions. Unfortunately, however, the densities of the different portions of the plate, which have received different amounts of light, are not proportional to the intensities of the light that has acted on them. Suppose, for instance, that the whole time of exposure be divided into a number of equal periods, say 20, it may happen that those portions of the plate on which the light has acted for, say, 17, 18, 19, 20 of these short periods, may be of practically equal density. The relation between the length of exposure—or rather the intensity of light acting on the film—and the density may be determined by exposing a plate behind a Spurge's sensitometer, and then developing the plate, different portions of which have received varying amounts of light, and placing it behind a condenser, such as used in magic-lanterns, and projecting a magnified image of it on a white screen. By a most ingenious instrument, devised by Captain Abney, and fully described by him in the Monthly Notices of the Royal Astronomical Society for March, 1889, the light which passes through each part of the negative can be compared with the light cast after reflection from a mirror by the same lamp on the screen, the intensity of this being reduced until it is equal to that which has passed through the particular part of the negative under examination, by means of a revolving disc formed of sectors, which can be opened or closed as required. Having obtained the relation between exposure and density by this means, we may represent it graphically by setting off a horizontal line (called, in plane co-ordinate geometry, the axis of x) distances measure from the left-hand end (called the origin) proportional to the time the light has acted on the several parts of the plates, and drawing from the right hand extremities of these distances vertical lines (called ordinates) proportional to the density of the several parts of the plate, and, joining the upper extremities of these ordinates, we shall find that these points do not lie on a straight line passing through the origin and inclined to the axis of x, but on a curve which at a certain distance from the origin tends to become parallel to the axis of x. If, instead of being a curve, it had been a straight line passing through the origin, and inclined to the axis of x, the length of exposure would have been a matter of indifference, as, supposing we wanted to get ten different degrees of density proportional to each other, it would not matter whether we took the ten intervals of time from the 6th to the 15th, or from the 15th to the 25th; all that would be required would be to stop the development, when that portion which had been acted on longest by the light had attained the desired degree of density, and the gradation of density in the other portions would be the same in all cases. If, however, it is found that the curve for any part of its course does not differ much from a straight line inclined to the axis of x, what has been described does take place between certain limits, and the plate allows some *latitude of exposure.* And in this case two similar plates exposed on the same view for different times, even though the exposure in one case is three or four times, or even more, what it is in the other, will give negatives scarcely, if at all, different from one another, even if developed in the same solution, the only difference being that, in the case of the plate that has received the longest exposure, the development is stopped sooner than in the case of the other. But if the exposure exceeds the limits indicated, it will happen that the density of the highest lights, and other parts which, though bright, are not so bright as the highest lights, will be the same, so that all gradation in the brighter parts of the picture is lost; if the exposure be further prolonged, what should be the middle tones will be almost as dense as the highest lights, and all proper gradation being lost, the picture will be flat. If the exposure be prolonged yet further, reversal will take place, but this is a phenomenon not very likely to be met with in ordinary work, as no one in taking a negative is very likely to give such an abnormally long exposure. What has been said, however, will account for the loss of detail in the skies of landscapes, for, in order to get the plate sufficiently impressed by the light proceeding from trees, houses, and foreground in the view, the sky will be so much over-exposed that gradation is lost in it, unless the sky itself is partly or entirely covered with dark clouds.

Over-exposure may be corrected to a great extent in the development, but how this may be done is beyond the scope of this paper. But though errors in time of exposure may be corrected, it is well to learn how to expose *correctly* for a normal developer, but with an alkaline developer it is difficult to say what is a *normal* one, hence I think that the beginner who wishes to learn how to expose had better at first use the ferrous oxalate developer, for it is very easy to say what is the normal ferrous oxalate developer, and also to make it; viz., thus, into a saturated solution of oxalate of potash pour as much saturated solution of sulphate of iron as you can without a precipitate being thrown down, or about one part of the latter to three parts of the former. But how can we distinguish an over-exposed or an under-exposed negative from one correctly exposed? It is often imagined that an under-exposed negative is dense, an over-exposed one thin; but this is not a safe guide. An under-exposed negative would naturally be *thin*, it is only in consequence of our prolonging the development, in the hope of getting detail in the shadows, that the high lights become dense, so, on the other hand, the over-exposed negative often owes its thinness to our not having dared to continue the development long enough for the high lights to become dense, lest we should lose the middle tones. The manner in which the objects appear as the development progresses is the safest guide. If the high lights first come up, and are followed gradually by the next highest lights, these by the next highest and so on, while the very darkest shadows remain unaffected by the developer, we may conclude the plate has been properly exposed. If, however, the highest lights and the next highest come up almost at once, and are rapidly followed by the middle tones, and the plate rapidly darkens more or less all over, the picture is over-exposed. If we fail with a prolonged development to get any detail in the middle tones, or even if we fail to get some detail in the shadows, other than the very darkest, the plate is under-exposed. But it may be said, this method only shows after the exposure of the plate whether it has been correctly exposed or not; how are we to determine beforehand what exposure to give?

Several methods have been proposed, exposure tables and actinometers being the favourites. In my opinion neither of these methods is trustworthy or necessary, both are often misleading; and, even if they answered the purpose, one serious objection, in my opinion, is that they tend to replace thought and judgment on the part of the photographer by a mere mechanical method, and by the unreasoning following of a set of rules, thereby depriving photography of one of its chief charms, the exercise of the intellect which it requires.

Each of these methods shall be considered in order, and then I shall endeavour to show "a more excellent way." Exposure tables may possibly save beginners from very egregious blunders, though even in this they are not always successful, as when once I found a photographer blindly following his tables and giving an exposure of three minutes with Ilford ordinary plates, on a bright summer day, with *f*/32, to a view of the east end of Tintern Abbey, on which an unclouded sun was shining through the space formerly occupied by the roof, simply because his camera was within the walls, and he regarded the view as a "well-lighted interior." The first difficulty generally is to make the view we are about to take fall under any of the headings in our tables, and, secondly, to determine what the compiler of the tables means by the light being good, dull, very dull, or gloomy. What one might call dull another might regard as very dull, and another even as gloomy. We can understand what is meant by bright sunlight, but if we are told to give four times as much exposure when the light is dull, it simply means that what the compiler regards as dull is light that requires four times the exposure needed when the sun is shining, so that his directions simply lead us, as it were, round in a circle. There are some tables, however, which are of more use, those that give the proportionate exposures required in bright sunlight at certain hours of the day and at different seasons of the year. These tables, compiled by different authors, agree much more closely with one another than the tables which take account of varying subjects and states of the light, owing to the presence of various thicknesses of cloud; but they are not to be trusted when the sun is anywhere near the horizon. In England it would seem that the actinic power of the sun at midday is least in December, that it increases gradually until about May, when it remains pretty constant until the end of July (the midday exposure required in the three summer months being only about one quarter that required in December), and that the light gradually loses power till we arrive at December again. In the summer there is not much difference in the light between 10 a.m. and 2 p.m., and in the winter not much difference in the light between 11 a.m. and 1 p.m., but when the sun is near the horizon the light loses a great proportion of its blue rays, which are those most effective in impressing an image on the plate, so that longer exposures must be given for a few hours after sunrise and before sunset. But it is well to notice that in some subjects—those, for instance, in which there are objects such as wide-spreading trees, which throw dark shadows on the ground beneath them when the sun is high—less exposure is needed when the sun's rays are more horizontal, so as to light up the shadow, or when there are bright clouds about the horizon, the reflected light from which has the same effect. For a similar reason it will be seen that a less exposure may often be needed when the sun is under a cloud, provided there be plenty of bright clouds about, than when the sun is shining from an unclouded sky.

Actinometers.—These are of two kinds, those in which a strip of sensitive paper is exposed to the light, and the time required for it to attain a certain tint noted, the requisite time of exposure of the plate being obtained by dividing this observed period by some number depending on the size of the stop and the kind of plate used. These actinometers, however, labour under a serious disadvantage; they measure, indeed, the *actinism* of the light which falls on them, but this may be very different from the light which is reflected from the various objects in the view, and which, passing through the lens, forms the image on the sensitive film.

The other kind of actinometer, or rather photometer, such as Decoudin's, does tell us something about the light that falls on the ground-glass screen, but unfortunately it tells us only about the *visual* rays, not about the *chemically* active rays.

A perfect instrument must have the power of measuring the *actinism* of the light which falls on the ground glass, but I have never seen or heard of such an instrument. Fortunately, however, there is a way by which we may determine our exposures while discarding exposure tables and actinometers. This method is simply to be guided by experience, assisted by carefully made notes of every plate exposed. Let us make it a rule never to expose a plate without entering in a book, subject, date, time of day, lens, stop, length of exposure; and after developing it let us note in the same book whether it was under, over, or correctly exposed. When taking a fresh view, one can almost always remember having taken a similar one under like conditions of light; all then that is necessary is to look back in the book for the exposure given, and the chances are no great error will be made if a similar exposure is given. If, however, no similar view has been taken, then one must make the best estimate one can, taking care to err rather on the side of over than under exposure, as it is easier to correct the former than the latter error by modifying the development.

It is absolutely necessary that the photographer should clearly understand the effect of stops upon exposure; the focal length of the lens and the relative diameter of the stops should be carefully measured by one of the methods already described in the competitive papers on lenses. If the diameter of the stops be expressed in terms of the focal length, as $f/8$, $f/11$, etc., then the relative exposures will be as the squares of the denominators of these fractions, in the example given, as 64 to 121, or nearly as 1 to 2. The precise form of the lens used has no practical effect on the length of exposure, but it is sometimes advisable with a long-focussed lens to give a longer exposure than with a short-focussed one, even though the relative aperture of stop to focus remains the same, in order that more detail may be obtained in the shadows, for if when we use a 4 in. focussed lens we have a shadow represented by a broad dark line or strip, say ⅛ in. in width, we shall scarcely notice any want of detail in it; but if we use a lens of 16 in. focus, this shadow will be ½ in. in width, and now the eye will expect to find detail and gradation of tone in it. Again, we must remember that when taking an object close at hand we may have to rack the camera out to such an extent that the ratio of aperture to the focus of the lens, as we are then using it, may be considerably altered; for example, suppose we are using an 11 in. focus lens, with a stop 1 in. in diameter, on a distant view, the ratio is $\frac{1}{11}$; but if we use the lens to photograph an object 3 ft. off, the distance between the optical centre of the lens and the plate will be about 16 ins., and the intensity ratio will be $\frac{1}{16}$, and an exposure of twice as long will be required. As I have not photographed beyond the boundaries of the British Isles, I have no practical experience of the varying actinic power of light in different latitudes, but those who have made experiments to measure the actinic power of light at various places assert that as we approach the equator the actinicism does increase but not in proportion to the increase in temperature. As we ascend high mountains, the direct rays of the sun have more and more actinic power the higher we go, but the diffused light from the sky loses actinic power. This is easily accounted for by the fact that the minute molecule, of the air reflect those light waves which have short wave length, while they permit the longer waves of light to pass, so that, according to Professor Langley, his opinion being based on experiments on the Rocky Mountains, if we could see the sun without the intervening atmosphere it would be seen to be a blue star instead of a white one, as it appears to us. In like manner the purer air to be found near the coast stops less of these valuable actinic rays than the air laden with more impurities, which we find in inland districts, especially in the neighbourhood of towns. Hence shorter exposures may be made near the coast.

Although it is impossible to draw up accurate tables of exposures, yet a few broad principles may guide us. Objects with dark shadows require longer exposures than more evenly illuminated views, distant views less than near ones, owing to reduction of the intensity of the shadows by light reflected from the intervening atmosphere, which reflected light, for the reasons explained above, is rich in blue rays, and gives a bluish colour to the distance. Sea, on account of its blue colour, and the light reflected from it, requires less exposure than land. The light reflected from the surface of a pond or river often lights up to a considerable extent what would otherwise be heavy shadows, and as it is a fundamental rule that we must expose for the shadows, so as to get detail in them anything that lessens their intensity will allow of a shorter exposure being given.

If we have an evenly lighted view deficient in contrast, shortening the exposure will increase the contrast, and prevent flatness in the resulting negative, while, on the other hand, increasing the exposure will soften down a view in which the contrasts are too strong.

Many photographers find a difficulty in timing exposures. Wishing to keep their eyes on the subject during the exposure, in order that they may re-cap the lens even before the full intended exposure has been given should anything suddenly move and so irretrievably ruin the picture, they cannot keep their eyes on the second hand of their watches; but I always count seconds in the following manner, and by it I can count even a minute with an error of not more than one or two seconds :—I repeat as fast as I can as many letters of the alphabet as I find from experience I can say in a second, thus, "a b c d e f, one;" "a b c d e f, two;" and so on up to ten seconds, then I begin a second set until the requisite number of seconds is completed. A little practice is all that is required to gain great accuracy by this method, the first idea of which I gained from Professor A. S. Herschell, who used a somewhat similar plan to count the time of the flight of meteors across the sky; and I should advise its use for exposures not exceeding twenty or thirty seconds—for longer exposures a watch is more convenient.

EXPOSURE.

Second Prize—W. A. WATTS, M.A.

THE question of "Exposure" is *one* of the most difficult, perhaps *the* most difficult, the beginner has to encounter. He may, upon the advice of an experienced friend, purchase his camera and lens of the very best; he may obtain his plates ready made, and by going to a good maker be assured of their quality; he may purchase his developer ready mixed, requiring only *brains* to make it work perfectly; he may even, if he distrusts his possession of the latter quality, send his plates to a professional to be developed; but he *must* expose himself, and *must* exercise his judgment, be it great or small, in determining the amount of exposure. General rules have, no doubt, been laid down which may guide him in his judgment, but these rules depend upon so many varying factors, and the variations are so frequent, and sometimes, apparently, so irregular, that the application of these rules can never be easy, and always require considerable discrimination. Many, and amongst them some of our most experienced workers, indeed, go so far as to say that no rules for exposure can be laid down, beyond the one golden rule, "Expose for the shadows, and let the lights take care of themselves;" and that all attempts to work by rule or calculation are misleading, and tend to produce a *mechanical* instead of an *artistic* result. They counsel the beginner to learn by experience only, of course in the process wasting many plates, and reduce all exposure to a rule of thumb, depending upon the past experience and instinctive feeling of the workman. These sentiments—proceeding, as they do, from men of great and long experience, and who, having gained their experience by many and painful failures, are now, no doubt, able to gauge exposure almost instinctively—are apt to have a depressing effect upon the beginner, who is anxious at once to make exposures with a reasonable prospect of success, and the writer of this, at all events, believes that it is quite possible to lay down the general principles of exposure, which, whether consciously or unconsciously, guide the experienced worker in forming his judgment, and which, by the exercise of a little discrimination, may gradually form for the beginner that *body* of experience which may eventually enable him, if he choose, to dispense with rules and calculations; although it is probable that, having once found the comfort of having definite guides for his judgment, and having become familiarised with the calculations necessary, which will thus cease to be a bugbear, he will prefer to make his exposures always on a scientific rather than a guess-work basis.

The two great factors of exposure are the intensity of the light which reaches the plate, and the speed of the plate itself. The former depends upon the brilliancy of the daylight, and therefore is modified by the latitude, the time of day and year, and the atmospheric conditions, whether cloudy or bright; it also depends, since we do not use the direct light of the sun, but reflected light, upon the character and d stance of the objects, or what is commonly styled the "nature of the subject," and, since it has to pass through a lens before it reaches the plate, upon the rapidity of the lens. The speed of the plate can only be found by experiment, and must be expressed in some definite ratio. We may thus enumerate the following items, which must be considered, whether consciously or unconsciously, before it is possible to form an intelligent judgment as to any required exposure, viz., character of subject, latitude, time of day and year, brightness or dulness of weather, speed at which lens is working, and speed of plate. Before considering how these factors vary, and how their effect may be estimated, it may be advisable to enquire, what is a correct exposure and how may it be determined? It will be found that when light of a certain intensity acts upon a plate for a comparatively short time it produces a certain effect upon the silver salt which is in combination with the gelatine, an effect not recognisable by the eye, but which, under the action of a reducing agent called a "developer," produces a more or less opaque deposit of either silver or sub-bromide of silver—it is not yet settled which. Supposing either the intensity of the light or the time of exposure be increased, the opacity of this deposit is increased up to certain limits. If, however, the intensity of the light varies, as if it proceeds from a landscape, some portions of which reflect more actinic light than others, then the varying opacity of the deposit will be approximately proportional to the intensity of the light; thus any black portions would produce no effect, and be represented by clear glass, whereas any portions of great brightness, such as a reflecting surface of water, would be represented by such a degree of opacity as will produce no effect upon the sensitised paper on which the print is made, and thus be represented by absolutely white paper. The more completely all the various gradations of light in the object are represented in the negative, the more harmonious and "well-graded" will such negative be, and it will represent an accurate exposure. We judge of exposure, therefore, by the complete gradation of the negative. We thus see that accuracy of exposure depends to some extent upon the development employed, and that each worker must estimate his *own exposures* in reference to his development, hence also a faulty exposure may be remedied by judicious alterations in the developer, but only within certain, and in some respects narrow, limits. Next suppose either that the intensity of the light has been too small, or that the exposure has been so short that whereas the brighter portions may be represented by a moderate degree of opacity, the darker portions have failed to produce any developable effect, the negative is lacking in gradation, and in the effort to secure sufficient detail, the portions which have been impressed by the light receive a very opaque deposit, thus producing what is termed a *hard* print. On the other hand, if too long exposure be given, the portions which have received least light, and which in a well-graded negative should be represented by clear glass or nearly so, become clogged up before enough time has been given to the development to secure opacity in the high lights, hence the gradation is lost at the other end of the scale, and the result is, if not very pronounced, a *soft*, or if more pronounced a *thin* negative.

The first attempt systematically made to state definite times for exposure appears to have been by Professor Burton, who several years ago published a table, from which the following is an extract:—

No.	Stop Ratio.	Sea and Sky.	Open Landscape.	Landscape with Trees.	Under Trees.		Well-Lighted Interiors.		Badly-Lighted Interiors.		Portrait Out of Doors.	Portrait in Studio.		Portrait in Room.	
		secs.	secs.	secs.	min.	sec.	min.	sec.	hr.	min.	secs.	min.	sec.	min.	sec.
1	*f*/4	1/160	1/50	1/8	0	10	0	10	0	2	1/6	0	1	0	4
2	*f*/5·6	1/80	1/25	1/4	0	20	0	20	0	4	1/3	0	2	0	8
3	*f*/8	1/40	1/12	1/2	0	40	0	40	0	8	2/3	0	4	0	16
4	*f*/11·3	1/20	1/6	1	0	80	0	80	0	16	1 1/3	0	8	0	32
5	*f*/16	1/10	1/3	2	2	40	2	40	0	32	2 2/3	0	16	0	64
6	*f*/22·6	1/5	2/3	4	5	20	5	20	1	4	5 1/3	0	32	2	8
7	*f*/32	2/5	1 1/3	8	10	40	10	40	2	8	10 1/2	0	64	4	15
8	*f*/45	4/5	2 2/3	16	21	0	21	0	4	15	21	2	8	8	30
9	*f*/64	1 3/5	5 1/3	32	42	0	42	0	8	30	42	4	15	17	0

This table embodies the result of many years' experience, but takes into account only two of the varying factors upon which exposure depends, viz., the different stop-ratios and the character of the subject; of course, at the same time, in such cases as under trees, and interiors, making allowance for loss of light due to such causes. Professor Burton, however, states that it is intended for the brightest sunlight, and for plates of an average rapidity, whose sensitometer number may be taken as 17 to 18 degrees. With duller light or with different plates allowance must be made. Professor Burton states that plates of 15° would require about double these exposures, and plates of 21° to 22° would require half, whilst plates of 24° to 25° would require only one-fourth. The table, however, is the basis of all the later ones, and before leaving it we may note that in the series of stops *f*/4, *f*/5·6, *f*/8, etc., each requires *double* the exposure of the preceding one, thus *f*/16 requires four times the exposure of *f*/8, whereas, as regards character of subject, if open landscape be taken as the unit of comparison, sea and sky requires rather less than one-third, whilst a landscape with near foliage will require six times as long, a portrait out of doors eight times, portrait in the studio forty-eight times, portrait in a room, near a window, two hundred times, views in a wood, "under trees," or well-lighted interiors, five hundred times, and a badly-lighted interior even up to six thousand times as much.

More recently tables have been prepared and published which take into account more completely the various factors of exposure by Dr. Eder, Scott, Platts, Thornton, Wormald, and others, the basis of which is generally an extension of Burton's table by Eder as follows:—

SUBJECT AND LIGHT.

Character of Subject.	Sunshine.	Diffused Light.	Dull.	Very Dull.	Gloomy
Sea and sky	¼	—	—	—	—
Panoramic view	1	2	3	4	5
View with thick foliage or strong foreground	2	4	6	8	10
View with dark buildings	3	6	9	12	15
Heavy foliage in foreground	4–5	8–10	12–15	16–20	20–25
Woods and badly lit river banks ...	10	20	30	40	50
Living objects outdoors	4	8	12	20	30
Portrait near a window	8	16	24	40	60
Interiors ... ... upwards of	100	200	300	400	500
Copying same size	6	12	20	—	—

Here it must be noted that the numbers are not *seconds* but *ratios*, which require multiplying with other factors to give the time of exposure. It will be seen that allowance is made for variations in brilliancy due to weather, according to a rough scale, by which diffused bright light requires *double*, dull light *triple*, very dull *quadruple*, and gloomy *five times* the normal exposure for the same subject and time of year. These numbers, of course, are not very exact, and only give a general indication ; more exactitude may be attained by means of an actinometer, whose indications also vary according to time of year and day.

The variation for character of subject depends partly upon reflecting power for light (thus sea and sky only require one-fourth the exposure of the unit landscape) ; partly upon distance (thus panoramic view, in which amount of reflected light does not greatly vary in different portions, and the whole of the light is compressed into a small space upon the plate, requires only half the exposure of *near* light objects, only one-fourth the exposure of an outdoors portrait, and only one-sixth that of copying same size) ; and partly upon want of illumination or non-actinic character of the light, as is shown by the relatively long exposure given to dark buildings, heavy foliage, woods, and interiors. The reason why near objects need a relatively longer exposure than distant ones is that the nearer the object the larger the image, hence the light proceeding from it is diffused over a larger space (*i.e.*, at half the distance, four times the space) on the focussing screen. The effect of variation in time of year and day is given in the following table by Dr. Scott :—

Hour of Day.		June.	May and July.	April and August.	March and September.	February and October.	January and November.	December.
12		1	1	1¼	1½	2	3½	4
11	1	1	1	1¼	1½	2½	4	5
10	2	1	1	1¼	1¾	3	5	6
9	3	1	1¼	1½	2	4	12	16
8	4	1½	1½	2	3	10	—	—
7	5	2	2½	3	6	—	—	—
6	6	2½	3	6	—	—	—	—
5	7	5	6	—	—	—	—	—
4	8	12		—	—		—	—

From which it will be seen that from the hours of 9 a.m. to 3 p.m. in June, and from 10 a.m. to 2 p.m. in May and July, there is no appreciable difference in the light. For earlier or later hours than these it falls off, as also in the other months of the year. Mr. Truman Wood states that there is no appreciable variation in the actinic intensity of the sun's light whenever its altitude is 54° or over, but that below that it varies in proportion as the sun's altitude is to 54° ; that is, at 27° it would be about half. Now the sun's altitude in latitude 52·30 (about the average for England) is 61° on June 21st, and it is about 54° on May 5th, and again on August 8th, just, therefore, including the three months named above. It is reduced to 27° when it has reached a south declination of 10° 30′, which the almanack gives on October 20th, thus agreeing with the table which assigns double exposure at noon in October. The same rule applies to differences of latitude, and exposure may be roughly judged by ascertaining the sun's altitude, which may be ascertained by the following rule: "Take the sun's declination at noon from the almanack; if of the same kind as the latitude, subtract it from the latitude; if of the opposite kind, add it to the latitude, and subtract the resulting number from 90°." Thus to find the sun's altitude in latitude 30° N. on December 1st, its declination is 21° 53′ S., this added to 30° gives 51° 53′, and this subtracted from 90° leaves 38°, which would require an exposure of about 1½ times.

Having considered the changes in intensity of light due to subject, season, and state of the atmosphere, the next point is the lens ratio. This affects exposure according to the well-known rule that if the focus of the lens be divided by the diameter of the stop employed, the times of exposure will be proportional to the squares of the quotients. Supposing the focus of the lens to be 8 ins., and the diameters of the stops respectively 1 in., $\frac{7}{10}$ in., $\frac{1}{2}$ in., $\frac{7}{20}$ in., and $\frac{1}{4}$ in., then dividing 8 in. by these numbers we get successively 8, 11·4, 16, 22·8, and 32, and the stops are usually marked *f*/8, *f*/11·3, *f*/16, *f*/22·6, and *f*/32, the decimals being slightly altered to agree with the numbers in Burton's table. They are more frequently, however, now-a-days marked according to the uniform standard of the B.P.S., which takes *f*/4 as No. 1, then *f*/5·6 is No. 2, *f*/8 No. 4, and so on; the advantage of the U.S. numbers being that they give directly the times of exposure compared with *f*/4. We may therefore prepare a short table as follows:—

Ratio ...	*f*/4	*f*/56	*f*/8	*f*/11·3	*f*/16	*f*/22·6	*f*/32	*f*/45	*f*/64
U.S. number	1	2	4	8	16	32	64	128	256
Times ...			1	2	4	8	16	32	64

The figures in the third line are those usually employed in exposure tables, being taken with *f*/8 as unit. The last point on which we must obtain information is as to *speed of plate*; this is the most difficult of all the factors upon which to decide. It should be ascertained once for all by each experimenter upon the basis of the development which he employs. Many makers profess to call their plates 30 times, 50 times, and so on, it being assumed that this is in terms of a *wet plate*, but these numbers are unreliable, as wet plates themselves vary, there is a general tendency on the part of makers to overestimate the speed of their plates, and different batches of plates seldom turn out alike. A more reliable plan is to test one plate of each batch by Warnerke's sensitometer, but even the indications of this instrument are open to doubt, owing to the fact that a true standard of light has yet to be discovered. When the sensitometer number is stated, which is done by several of the best makers, or ascertained by experiment, it must be borne in mind that these numbers are *not ratios*, which must be determined by plotting a curve, but a fair approximation is that 15° indicates about "ten times," 17°-18° "fifteen times," 21°-22° "thirty times," and 24°-25° "sixty times."

Having ascertained or estimated the various factors required, the exposure may now be calculated. Multiply together the subject number, allowing for brightness, the number representing time and season, and the stop number (in third line above), and divide the product by the number representing speed of plate; the quotient will be the approximate exposure. An example may render this clearer. Suppose we have a view consisting of cottage with trees, time 4 p.m. in March, stop ratio *f*/16, and plates showing 22 on sensitometer. Light, bright diffused, but not sunshine. We find in Eder and Burton's table, view with buildings, in second column, 6; in Dr. Scott's table, March, 4 p.m., 3. Underneath stop ratio *f*/16 we have 4 times, and speed of plate is 30.

Now $\frac{6 \times 3 \times 4}{30} = \frac{72}{30} = 2\frac{1}{2}$ nearly—so $2\frac{1}{2}$ seconds would be about right. Burton in his first table gives 2 seconds for *f*/16, "landscape with trees;" but this must be halved for speed of plate, and result at least multiplied by 3 for difference of light, which gives a result not very far from that just found.

In order to facilitate these calculations, various sets of "exposure tables" have been published. Some, such as Platt's, Thornton's, Cartwright and Rattray's, give the separate tables with more or less information to enable each worker to make his own calculations. Others, such as Wormald's, "Viæ's," etc., give exposures ready calculated. Wormald's, for example, gives a separate table for each month in the year, showing at a glance the estimated exposure for each stop ratio at every hour in the day. These are calculated for 30 times plates, and for near subjects, such as buildings with trees, and bright sunshine. For any other plates, or a different class of subject, or dulness of weather, allowances have to be made. For the example given above, Wormald gives one second, which must be doubled on the ground of the light being only diffused bright light, not actual sunshine.

As to the utility of exposure tables, much difference of opinion exists. Some look upon them as "feeding bottles" or "swimming corks," to be discarded so soon as a little experience has been gained. The writer's view has already been intimated; he believes them invaluable for the beginner, as giving in a concise form the results of the accumulated experience of the best workers, and he looks for their further improvement, so as ultimately to give a scientific expression to the exposure necessary when all the conditions admit of being accurately stated. Before, however, this can be realised, standard units of light and speed of plates must be found, and these factors must admit of accurate statement. Some attempts have been made to determine the light by means of actinometers; these generally consist of a slip of sensitised paper and a scale of tints or standard tint for comparison; the number of seconds required to attain a certain tint supplies one of the factors. Stanley's actinometer consists of a strip of bromide paper soaked in nitrite of potassium, which causes it to print rapidly in daylight, and Ackland's tables are graduated to work with it. Woodbury's, Fuidge and Green's, and the "Bijou" work with ordinary silver paper. The maker of the latter states that $\frac{1}{10}$ of the number of seconds required to attain the standard tint forms a multiplier for subject number and stop ratio, which must be divided by speed of plate, the number given being 40 for 50 times plates and 20 for ordinary. Thus, in the example given above, if the actinometer took sixty seconds, one-tenth of that is six, and we should have had $\frac{3 \times 6 \times 4}{20} = 3\frac{3}{5}$, rather longer exposure than previously found, but, as has been explained, the speed number must be found according to the development; using 30 instead of 20 would bring it very nearly to our previous conclusion. In using Fuidge and Green's, $\frac{1}{10}$ of time to attain the fourth tint, or with Woodbury's the third tint, gives about the same results.

The use of the actinometer, however, is open to the objection that the sensitive substance is silver chloride, and not silver bromide, and the scale of sensitiveness therefore is different from that of gelatine plates. In the duller lights silver paper appears to take unduly long in proportion, and therefore to lead to over-exposure, unless allowance is made. The discovery of an accurate actinometer and a workable standard of light intensity is one of the wants of scientific photography. Messrs. Hurter and Driffield have attempted to solve the problem with their Actinograph, but the instrument has not been long enough before the public to allow an authoritative opinion on its merits.

In conclusion, perhaps the best way to get a useful estimate of the speed of plates with which one is working is to take some one really *successful* exposure. Note the time it took in seconds and the various factors, multiply these together, and divide by the time; the result is "speed of plate." Use preferably one taken in brightest weather and with small stop. If, for example, subject classed 3 in bright day in June, stop ratio *f*/32, took two seconds, we have $\frac{3 \times 1 \times 16}{2} = 24$, which represents approximate speed of plate, suited to development employed, and may be used in further experiments.

COMPETITIVE PAPER No. VI.

DEVELOPMENT.

First Prize—H. E. MURCHISON.

When the amateur photographer begins to understand what development really ought to be, the progress of photography towards art will appreciably quicken. The theory of development is no doubt extremely interesting. The reduction of the silver haloids; the vibration of the molecules of the sensitive salt contained in a film of gelatine, commenced by the action of light, and revealed by the action of other salts, has supplied many a clever scientist with a field for investigation. All honour to them. But to the photographer development should not be a chemical experiment; he should not think of chemistry when developing, any more than the painter thinks of the spectrum while painting. Not that the former does do so *as a rule.* He troubles himself little about chemistry, and he thinks just as little about art.

The average amateur (to whom I have been referring more particularly), indeed, thinks not of equations, nor does he trouble himself any the more with the artistic side of development. It must be confessed that he regards it as a kind of automatic machine, or else he gives it no more importance than a fixing bath, measures it by rule of thumb, by chance controls it, and not by any exercise of the will. Fancy a painter who valued painting on a level with varnishing! The whole process of photography is from beginning to end looked upon by many as a kind of, well, shall I say gymnastic exercise—first motion, straddle the tripod; second motion, open the camera; and so on. But even where an intelligent choice is made of a point of view, and thought has been bestowed upon the composition of a picture—and not merely in one case, but where thought and intelligence are habits—even then a plate is not developed in the true sense of the term, but may be said to be "done," like a leg of mutton. Some correspondent of yours the other week recommended a ready-made-up solution with the words, "One lot of the developer will *do* six plates." Poor plates!

It is by an intelligent use of the agents that have been placed in our hands for revealing the latent image, and by a knowledge of the power and meaning of the several constituents of the developer that an artistic picture is to be made out of what the sun has done for us. And that is not all; even to those whose ambition does not rise so high, this knowledge is a power working for certainty of results, which must be a commendation to all who wish to limit the number of spoilt plates; I take it, everybody. The ideal developer, broadly speaking, is one which can be controlled, which will give a good negative, remain clean and transparent until its work is done, and which shall be as simple in composition as possible. Simplicity is everything, eschew all complications, and ignore all things, such as glycerine, which are recommended by some people. There are four component parts of a developer such as will most nearly satisfy the conditions named above. They are (1) pyrogallic acid, (2) bromide of ammonium (or potassium), (3) sulphite of soda, and (4) liquor ammonia. Of these, numbers 2 and 4 should be kept in 10 per cent. solutions, dissolving an ounce of bromide in 10 ozs. of water, and adding 9 oz. of water to one of ammonia. Of No. 3 it is impossible, as has been pointed out in these columns, to make a 10 per cent. solution, as 10 ozs. of water become saturated with the salt before an ounce of it has been dissolved. We must keep this, then, as a 5 per cent. solution. As for pyro, this should be kept dry. No matter what preserver, so called, may be used, a change commences directly pyro is dissolved in water, and goes on steadily working a deteriorating effect upon the main vital essence of the developer, and introducing an element of uncertainty into that same. I have tried pyro with citric acid, sulpho-pyrogallol, pyro with I know not what, but sooner or later would come poor results mysterious in their origin, but which no longer follow on the use of the dry chemical. Many object to the trouble of weighing pyro every time a plate is to be developed, but in practice this is no trouble to speak of, and an accurate idea of what is one, two, or more grains is soon arrived at.

Bromide of ammonium or potassium may be used indifferently, though, if a choice is to be made, use what the maker recommends. Sulphite of soda is a *sine qua non*, for it keeps the solution clear, the fingers clean, the plate free from stain, and helps to produce a negative which cannot be beaten for quality, especially if platinotype be the printing process adopted. We cannot be too grateful to Mr. H. Berkeley for having first pointed out the use of this salt, though it *is* unstable. It deteriorates rapidly as a salt, becoming *sulphate* of soda; and even in solution, used when getting towards the bottom of the bottle, it has sometimes been known to take the power from the developer. It should be mixed, therefore, in small quantities, and not drained to the dregs.

Liquor ammonia still holds its own as an alkali, though the carbonates of soda and potash are making a steady assault on its position. There is no particular reason why we should abandon our old friend. The carbonates may have their advantages, though they get no pull over ammonia through being less volatile, because, as will be explained, it matters not even if the ammonia is losing some strength every day it remains on the shelf, provided the stopper is not left out, or the ammonia of a *very* feeble kind.

A normal developer for ordinary landscape work may be composed in these proportions of the above four constituents :—

Pyrogallic acid		2 grs.
Sulphite of soda (5 per cent sol.)	160 minims =	8 „
Brom. am. (10 per cent. sol.) ..	20 „ =	2 „
Ammonia (10 per cent. sol.) ..	As hereafter stated.	
Water	1 oz.	

Add the pyro last. You will then find this to be none of your sherry-coloured solutions, but clear as the water itself, keeping nearly as clear until the end.

A fairly accurate simile of the control of the photographic artist over his developer is supplied by the control of the engineer over his engine. The engine is mechanical, it is true, but it may be made to go slowly or quickly as the guiding mind may decide. In our case, pyro may be said to be the engine and ammonia the steam. For pyro, the moving force, is *practically* powerless without the infusion of some vitality, which is supplied by the ammonia. Bromide is a safety valve, and keeps the boilers from bursting. But the motto of intelligent development is, keep your finger on the regulator and don't let all the steam in with a rush. *Have* a safety valve, but don't depend upon it to keep the engine from running away.

Add your ammonia by degrees. Begin, if you like, with half a a grain to the ounce, coax out your negative, hang over it with tender care, watching its every phase, quick to add a drop or two of ammonia just when the time comes. But *don't* put in all the ammonia given in a formula at once, and then, when over-exposure shows itself, panic stricken, dash in half a bottleful of some restrainer. Such a course may save a plate, but it will spoil the quality of the negative. There is *no* certain quantity of ammonia that can be recommended with a developer, and therefore you can't add it at first. The correct amount is that which will serve to completely and successfully develop the particular plate under treatment. Sometimes it may be 2 grs., sometimes 3. Neither does it matter if the ammonia solution has lost some strength or is not of the regulation ·880. If it be weaker, then a drop or two more will be wanted to complete the work; if stronger, a drop or two less. But remember one thing while you are outdoors, and that is, *always fully expose.*

Hydroquinone is a developer which is rapidly gaining ground in this country, and certainly, where plates are under or instantaneously exposed, it seems to supply a reducing agent of great energy. In such cases as mentioned, then, it may profitably be employed, but for ordinary purposes it is too mechanical. It need not be altogether so, any more than ferrous-oxalate. This seems to enjoy favour by fits and starts. There was a series of articles by Mr. S. Bottone in the *Photographic News* some years ago, in which its use was strongly championed, and certainly, by his efforts, it was raised from out of the position of a mechanical developer pure and simple. It was pointed out that an extremely strong developer might be made by dissolving crystals of ferrous-sulphate in oxalate of potash, and that the bromides would restrain to a great extent; in fact, the author went so far as to place it before pyro in convenience. But whether it be owing to the dirty character of the ferrous-oxalate developer or the demand for one which shall be more capable of modification, whatever may be the reason, it is now seldom spoken of or written about.

No, neither hydroquinone nor ferrous-oxalate will entirely supplant in general use the pyro-ammonia developer, if only the last-named is properly used in conjunction with a full exposure of the plate. When a plate is under-exposed, pyro-ammonia supplies a developer which, properly constituted, has only been surpassed in a testimonial as yet, although I am not wishing to underrate the evidence. Even in cases such as we are now considering, is there any necessity to add a large quantity of ammonia all at once? Reduce the bromide to a minmum, go on adding the ammonia by degrees, and the result will be a negative much fuller of detail and richer in gradation than one developed slap-dash. It is just in these qualities of manifold detail and richness of gradation that a gradually developed plate peculiarly excels. There are no great leaps and bounds between the tones, but a gradual sliding along the scale, and yet there is more contrast. The highest light is brighter, and the deepest shadow is darker, than in a quickly developed plate, and yet there is no hardness. But if you *do* want, for a particular reason to lessen the gradation, here then is your power—put on more steam. If more contrast be wanted, or if you have to deal with a plate notoriously over-exposed, go as tenderly as a driver taking his engine over some dangerous points at a great junction. Bromide increased is another help in cases of over-exposure, and so is pyro, for pyro gives density and restraint.

The knowledge of the density-giving power of pyro ought to stand the photographic artist in good stead in his different treatment of different subjects. There are some views which, even on the ground-glass, are so full of beautifully balanced contrasts, that instinctively it is felt that, barring accidents, a good negative *must* result. For instance :—Here are some stepping stones leading across a stream to a path up to some thatched and whitewashed cottages on the left, backed by some of those tall poplars which so delightfully help in composition. In the right foreground is a belt of rushes. The afternoon's sun's oblique light gives every stone, every blade of grass, a shadow and a distinctiveness, and by shining upon the side of the grey church tower, just peeping above the belt of trees up at the back, gives us a consciousness, and nothing more, that there *is* a church there. Now when you get the plate exposed upon such a view into your dark-room, use your normal developer, and use it with care, and the resulting negative should be "a thing of beauty and a joy for ever." But perhaps on a summer's holiday, when objects of interest rather than pictures are the desiderata, and when things have to be taken as they are found, or not at all, a street view has to be obtained. A blazing hot sun lights up one side of the street, some of the houses in which may be whitewashed, the other side is in shadow, only relieved by reflection from the whitewash. Use only half the pyro in such a case, bring up all the details to what is considered their true intensity ratio, and *then*, if there be a general lack of vigour (without fog) all over the plate, add the rest of the pyro. A general intensification will take place, and will proceed at the proper rate of speed for each tone of light in the view, if the original development has been started at the proper rate.

Again, a photograph has to be obtained of a grey old ruin on a cloudy day. A knowledge of the density-giving power of pyro would lead us to increase the quantity of it in the developer; but this should be accompanied by an additional quantity of bromide, and the principal idea of development in this case should be to make a distinct interval between the tones of light intensity reflected from the subject, for if they merge into one another the result is flatness. On the other hand, if too great intervals elapse between the tones, the result is hardness.

The power of taking advantage of the lighting of one subject, or of making up for the differences (either through too much or too little light) of another will lead the photographic artist to more advanced ideas. He will seek to create more original effects of his own, and much already has been done in creating the idea of atmosphere, for example. The impressionist school seek atmosphere in fuzziness of focus, and although this idea is not to be scoffed at, still, it seems more true to seek to place a veil over the distant parts of the photograph than to slur them over. The painter who scrumbled his distance with a faint bluish mist would be truer to nature, surely, than he who painted it with the same tones as the other parts of his picture, but in a more sketchy manner? And this seems to be the difference between fuzziness of focus in the distant parts of a photograph, and the production of atmosphere by skilful use and control of the developer. Upon that developer simplicity in constitution will give a tighter grasp, knowledge of the parts will give a power over the whole, and the vital essence of that whole is pyrogallic acid. Do not depend upon retarders after development has commenced. Use a retarder, but seek rather to render after-correction a thing unnecessary by control over the moving force—ammonia.

DEVELOPMENT.

Second Prize—F. T. BENNETT.

Development, in a photographic sense, means the art of bringing out and fixing the latent image in a plate which has received an exposure in the camera.

If a plate be examined after it has been exposed, it will be found impossible to detect that any change has taken place. There are several theories put forth as to the actual change which does take place when a plate is exposed, a very popular one being that of an electrical action being set up, and to that theory I myself lean.

There are several developing agents in use at the present day, the best known of which are pyrogallic acid, hydroquinone, and iron. Though the hydroquinone is comparatively new in the field, it has already found many admirers.

In both pyrogallic acid and hydroquinone developers (neither of which reducing agents alone would develop a plate satisfactorily), there is added an accelerator, such as carbonate of soda, potash, sodium hydrate (caustic soda), or ammonia.

It is also necessary to have a restrainer, such as bromide of ammonium, or bromide of potassium, without which we should find great difficulty in bringing a negative up to printing density.

There is also another ingredient which is not absolutely necessary, namely, sulphite of soda. It acts slightly as a restrainer, but it is added to a developer to prevent the plate being stained. Many workers, and among them a considerable number of professionals, use little or no sulphite, preferring the printing quality of a yellow negative.

If the development be prolonged with a developer without sulphite, the stain is so bad at times as to make the printing very slow, but it can be readily removed in any ordinary clearing bath. The following is a simple and efficient one—

Saturated solution of (common) alum	2 ozs.
Hydrochloric acid	1 oz.

Which bath may be used repeatedly until much discoloured.

For the production of beautiful-looking negatives, lantern-slides, transparencies, opals, bromide paper prints, and enlargements, the iron or ferrous-oxalate developer is generally used, because of its non-staining quality. Its drawback for negative work is the little chance it gives of modifying it to correct over and under exposure. The following are the proportions:—

Neutral oxalate of potash	10 ozs.
Water (warm)	30 „

Label "P" (potash).

Proto-sulphate of iron (ferrous sulphate) ..	3 ozs.
Citric acid	60 grs.
Water	10 ozs.

Label "I" (iron).

The above solutions are used in the proportion, three parts of P to one part of I. Thus to develop a half-plate, pour into the measure $1\frac{1}{2}$ ozs. of P, and $\frac{1}{2}$ oz. of I, being careful to remember to pour the iron into the potash, not *vice versa*, otherwise the developer will be at once spoiled.

With a plate which has been correctly exposed, you may be sure of getting a clean, sparkling image with the iron developer, which may be used again and again until its strength is exhausted.

In case of under-exposure, a thing not uncommon in England, where the light is very poor and instantaneous exposures are made, have at hand a solution of 20 grains of hyposulphite soda to 1 oz. of water, and to each ounce of the developer add from 10 to 20 drops. You have then one of the most powerful detail-giving developers known, and you may rest assured that the full result of the exposure will be brought out. The negative can then be brought up to proper density by intensifying it with mercury and ammonia. If, on the other hand, you find the plate over-exposed and developing too quickly, have by you a solution of restrainer, 20 grs. of bromide of potassium to 1 oz. of water, and into each ounce of the developer put about $\frac{1}{4}$ drm.

Negatives produced by iron development are crisp, sparkling, full of soft half-tone, and of olive-green tinge, though they do not possess, to my way of thinking, the printing quality of a negative developed with the pyro-ammonia developer.

The most generally used, and, in my humble opinion, the best developer for negative work is the pyro-ammonia developer. It is capable of modification to almost any extent. It is also very cheap, recommending itself strongly to the professionals, and all who desire to secure the best results at the lowest cost. Above all, it is a developer which gives a printing quality to a negative unequalled by any other mode of development.

Pyro may be used with almost any alkali, such as carbonate of soda (common washing soda), potash, caustic soda, or ammonia. The following will be found to be a thoroughly good working formula of a pyro-ammonia developer, which has given good results with every brand of plates with which I have used it.

Dissolve 4 ozs. of re-crystallised sulphite soda in 12 ozs. of warm water, and when cold neutralise with citric acid, which is done by adding small doses of the citric acid until there is no change of colour if a line be drawn upon neutral test paper; should the test paper turn blue, more acid must be added, but if red, too much acid has been used (which slows the developing). When cold, add 1 oz. of pyrogallic acid, and label "Pyro."

Bromide of potassium	1 oz.
Water	16 ozs.

Label "Bromide."

Ammonia (880)	$1\frac{1}{2}$ oz.
Water	16 ozs.

Label "Ammonia."

To develop, use the above in the following proportions:—

	Pyro.	Bromide.	Ammonia
Under-exposure	$\frac{1}{4}$ drm.	$\frac{1}{2}$ drm.	$\frac{1}{2}$ drm.
Correct exposure..	$\frac{1}{2}$ "	$\frac{1}{2}$ "	$\frac{1}{2}$ "
Over-exposure	1 "	$\frac{1}{2}$ "	$\frac{1}{4}$ "

(To 2 ozs. of water.)

It is better, in making a developer, to use distilled or boiled water, as in ordinary tap water there is so much impurity, which causes the developer to deteriorate in quality.

The above quantities are sufficient to develop 100 half-plates.

The following simple formula is the one I generally use for instantaneous work:—

Water	20 ozs.
Sulphite soda	$\frac{3}{4}$ oz.
Bromide ammonium	$\frac{1}{2}$ "
Ammonia	$1\frac{1}{4}$ "

Using 1 drm. to the oz. of water, and dry pyro till sufficient density be obtained, usually taking from $\frac{1}{2}$ gr. to $1\frac{1}{2}$ gr.

With plates which will stand sodium hydrate (caustic soda) substitute 1 oz. for the $1\frac{1}{4}$ oz. ammonia. If development be continued for an exceptionally long time, the negative will be slightly stained and, therefore, of greater density, on account of its yellowness, than it appears by transmitted light.

A very clean and good developer is the pyro and potash, and I do not know of a better formula than that by Beach, as follows:—

PYRO SOLUTION.

Warm distilled water	2 ozs.
Sulphite soda	2 „
When cold add	
Sulphurous acid	2 „
Pyrogallic	½ oz.

POTASH SOLUTION.

Carbonate potash	3 ozs.
Sulphate soda	2 „
Water	7 „

Dissolve the salts separately, and then mix. For normal developer take 1 drm. of pyro solution and make up to 2 ozs. with water, adding 20 minims of potash solution. For under-exposure use more of the potash solution, and for over-exposure *vice-versa*.

A thoroughly good hydroquinone developer is the following :—

(1.)

Hydroquinone	160 grs.
Sulphite soda	2 ozs.
Citric acid..	60 grs.
Bromide potassium	15 „
Water (to make)	20 ozs.

(2.)

Carbonate potash..	2 „
Ordinary washing soda	2 „
Water (to make)	20 „

Take 1 oz. of each solution, and add 3 ozs. of water for use. When the plate is sufficiently developed, it is washed for a few minutes, and fixed in a bath of

Hyposulphite soda	5 ozs.
Water	20 „

And when thoroughly fixed (all the whitish opacity removed), wash in running water for about one hour, and place in the draining rack (out of the dust) to dry slowly.

The power to correct too much contrast and want of contrast is very great with the pyro developer. Take, for example, a portrait of a lady with a dark, sallow skin and white dress. If developed with a normal developer in the ordinary manner, as though no great contrast existed, we should get a negative better suited to the dust-hole than the printing frame. The dress would be so dense as not to print at all, while the face would be much over-printed.

One way of correcting would be to slightly over-expose; that is to expose for the yellow skin, by which time the white dress would be much over-exposed, and, as every school-boy knows, an over-exposed plate, or portion of same, develops thinly, so we see that by simply over-exposing, the contrast to an extent is cancelled.

A better way to correct is in development thus: commence development with a rather weak developer, very weak indeed in pyro and bromide; and here let me say care is necessary, or fog will result. Watch patiently, adding small doses of the accelerator till all the detail you require is obtained. The negative will then be thin all over, which will simply need to be strengthened up with a dose of pyro and bromide, so that by simply keeping back the pyro we can modify the contrast to almost any extent. One more way is by using a small stop in the lens, but for portraiture it is of no use for two reasons; firstly, that it gives too much detail to be artistic; secondly, that it makes the exposure too long.

To produce contrast we slightly under-expose or develop quickly, by keeping back the accelerator, and using a developer strong in pyro and bromide.

Take, for example, the portrait of a person with a red skin, yellow or black dress. If a full exposure be given, a flat result will be obtained, the person having the appearance of having been flattened into the background.

To correct the flatness and produce contrast, slightly under-expose, using a fairly large stop in the lens, and develop with the developer strong in pyro and bromide, using a fair dose of the accelerator at the last moment to bring out the details

In speaking of the merits of various formulæ, we have a difficult subject in hand, as most, if not all, the makers of dry-plates issue a formula with them best suited for their development. Some of them advise a weak developer, while some advocate one strong in all its constituents. For my part I am in favour of a strong developer handled with care. I can speak from practical experience that the Ilford plates developed with the makers' formula will give results that leave nothing to be desired. I do not for one moment disparage the goods of other plate makers, but simply wish to say that I am able to obtain better negatives with the Ilfords, finding them easier to work and capable of bearing a stronger developer (one which contains caustic soda) without frilling or staining.

A simple arrangement I have found of use when developing very rapid plates is to cover the developing dish with a sheet of orange or ruby glass let into a cardboard lid, for any rapid plate, if exposed for a sufficient length of time even to a ruby light, will be affected by it.

After the development has fairly commenced, a brighter light may be used with safety. I find it best to work with all the light obtainable (that is safe), to be able to correctly estimate the density.

Makers of glass-bottomed dishes speak loudly in their favour, but I have found it difficult to judge of the density owing to the darkening of the developer.

In conclusion, I must place pyro-ammonia as the best negative developer, and leave iron and hydroquinone (for the development of bromide papers, opals, lantern slides, etc.) to fight the place battle, giving the preference to the iron developer.

DEVELOPMENT.

Third Prize—W. A. WATTS, M.A.

DEVELOPMENT is the complement of exposure, the best photographic result being attained by a normal exposure followed by a standard development; at the same time, under-exposure may be to a certain extent corrected by strengthening the developer, and, on the other hand, even very considerable over-exposure may be neutralised by judicious alterations in the developer.

Exposure and development are the two handmaids of the photographic art. The artist conceives and arranges the picture, they execute the result. It is in the composition of the picture that the artistic side of photography is seen, whilst in exposure and development the scientific skill of the manipulator becomes evident. The latter, being governed by the laws of optics and chemistry, are capable of exact definition and mathematical expression; the former, being a branch of art, is free as the mind of man, limited only by intellectual conceptions of beauty. The more fully this distinction is observed and insisted on, the more fully does photography rank as an *art-science*, in its one aspect governed by law, in its other offering free scope to the imagination, instead of a mere "rule of thumb" mechanical operation capable neither of artistic imagination nor photographic exactness.

The chemical principle upon which a developer acts appears to be this: the sensitive salt of silver—which, at all events in most commercial plates, we may assume to be silver bromide (AgBr)—undergoes a change by the action of light whereby the affinity between the silver and the bromine is weakened; no actual decomposition appears to take place—at all events, in the brief exposure which a plate receives in the camera—but the decomposition is in a latent condition, so to speak, requiring only the assistance of a substance possessing an affinity for bromine to start it. Such a substance is found in the developer, whose active constituent possesses an affinity for oxygen and therefore for bromine. The simplest developer is, perhaps, the ferrous oxalate, and the action of that is sufficiently similar to the others to serve as an illustration. Iron forms two oxides, ferrous and ferric, the latter containing more oxygen than the former. Each forms its own series of salts, which possess this property, that the ferrous salts are easily changed into the ferric salts either by the action of oxygen or bromine, chlorine, or similar substances. Thus—

$$2FeSO_4 + O + H_2SOFe3S0 \quad H\ O.$$

Bromine acts similarly, either, as some suppose, by actually taking hydrogen from water and so giving oxygen to the ferrous salt,

$$2FeSO_4 + 2Br + H_2O + H_2SO_4 = Fe_2 3SO_4 + 2HBr + H_2O,$$

or by forming a ferric bromide with *part* of the iron, thus leaving extra sulphuric acid for the remainder,

$$6FeSO_4 + 6Br = Fe_2Br_6 + 2Fe_2(SO_4)^3.$$

Now *ferrous* oxalate acts similarly to ferrous sulphate, being capable of taking up Br and being converted into *ferric* oxalate,

$$6FeC_2O_4 + 6Br = Fe_2Br_6 + 2Fe_2(C_2O_4)_3.$$

Substances which thus tend to take up oxygen, bromine, chlorine, etc., are called *reducing agents*, because when their action is sufficiently powerful they will deprive such substances as silver chloride, or silver bromide, of their chlorine or bromine, thus *reducing* them to metallic silver.

The developer, then, contains a reducing agent not sufficiently powerful to deprive silver bromide, which has been shielded from actinic light, of its bromine, but sufficiently powerful to abstract it from silver bromide, whose affinity has been weakened by the action of light, and so modified that instead of acting irregularly or equally all over the plate, it will reduce most completely that silver bromide which has been most exposed, and less so that upon which light of less intensity has acted, thus giving a picture the intensity of the opaque portions of which is exactly proportional to the intensity of the light which has fallen upon them. It will be obvious that although in a case where the exposure has not been quite enough, it may be possible by strengthening the developer to secure a more powerful action, and so to compensate to some extent for the insufficient action of light, yet if the affinity has not been shaken at all, no developer, however powerful, can produce any effect, unless powerful enough to fog the whole plate; but, on the other hand, when exposure has been too prolonged, and the affinities very much weakened, unless decomposition has actually set in, it ought to be possible by sufficiently weakening the developer to lessen its action so far as to compensate for the over-action of light.

The other developers, pyrogallol, quinol, etc., act in the same manner as ferrous oxalate, viz., as reducing agents, taking up the bromine by reason of their affinity for oxygen, but the action is more complex, and not so easily to be expressed in an equation, as the products of oxidation are not so definite. The result, however, is the same, bringing about the reduction of the silver bromide in proportion to the action of light. It is not quite certain what substance is actually formed in the lights of the picture by the reducing action of the developer. Many chemists maintain that the silver bromide loses its bromine and becomes converted into metallic silver, thus:

$$AgBr = Br = Ag.$$

The silver must, if this be so, be deposited in very fine particles, as its colour is nearly black, and has generally nothing metallic-looking about it. Still, the appearance of the image in a wet plate, particularly when the developer is strongly acid, is very silvery-looking, and it may be only the greater energy of the alkaline developer used with dry plates that causes the deposit to be very finely divided. It is known, for instance, that finely-divided platinum is perfectly black, as in the platinotype.

The more modern view, however, inclines to the supposition that a sub-bromide of silver is formed according to the equation,

$$Ag_2Br_2 = Br = Ag_2Br.$$

Certain theoretical chemical considerations are against this view, which can hardly be considered firmly established.

In developing wet plates, an acid solution containing either ferrous sulphate or pyrogallol is employed; the reducing action being as above explained—the reducing action, however, is more energetic in an alkaline solution, and no doubt part of the superior speed of the modern dry plate is due to the alkali, which is added in all the forms except the ferrous oxalate.

Having considered the chemical action of developers generally, let us examine more particularly into the kinds of developer generally used. They may be classified under three heads, according to the nature of the active ingredient or reducing agent, viz., Ferrous Oxalate, Pyrogallol, and Quinol developers.

Ferrous Oxalate Developers.—The reducing agent in these is, as previously explained, ferrous oxalate. FeC_2O_4, which by taking up bromine becomes converted, at all events partially, into ferric oxalate, $Fe_2(C_2O_4)_3$. Ferrous oxalate is a yellow-coloured powder formed by adding ferrous sulphate to potassic oxalate,

$$FeSO_4 + K_2C_2O_4 = K_2SO_4 + FeC_2O_4.$$

It is insoluble in water, but can be dissolved in a strong solution of potassic oxalate.

The most energetic form of this developer is made by dissolving in a saturated solution of potassic oxalate as much of this yellow powder as it will take up. As this, however, is a troublesome method, it is more generally obtained by adding to an excess of strong solution of potassic oxalate only so much saturated solution of ferrous sulphate as will produce *not more* ferrous oxalate than the excess of potassic oxalate is capable of dissolving. With saturated solutions of both there must be at least three times as much potassic oxalate as ferrous sulphate, but it will be found a convenient strength to make each of them 1 in 4 (that is 1 oz. of ferrous sulphate in 4 ozs. of water, and 4 ozs. potassic oxalate in 16 ozs. of water), and then to add to a measured quantity of the latter one-fourth its bulk of the former.

The ferrous oxalate developer is uniform in its action, and is very simple in use. With properly exposed plates it gives good results, free from fog and staining, but is not susceptible of much latitude, as, beyond weakening it with water, or adding less iron, relative proportions cannot be altered materially, for in trying to strengthen it with more iron the ferrous oxalate would be thrown down. Its action can, however, be checked by addition of a solution of potassium bromide, which has a valuable property in helping to keep the unexposed portions clear; and it can be materially hastened in cases of under-exposure by addition of a drop or two of solution of sodium hyposulphite. The theory of the action of this latter substance is not well understood, but it probably acts by partially *dissolving* the silver bromide and so rendering it more rapidly acted upon by the reducing agent, and no doubt ammonia in the alkaline developers acts in a similar way. The theory of the restraining action of soluble bromide will best be dealt with in describing the pyrogallol developer Ferrous oxalate is particularly valuable in developing *positives*, such as lantern transparencies, bromide enlargements, etc. The black tones of colour which it produces, and the clearness of the high lights are its principal characteristics. Great varieties of tone may also be produced by additions, such as ammonium chloride in the Edwards developer, and ferrous citrate in the developers for gelatino-chloride plates. Cowan directs for cold tones, potass. citrate 136 grs., and potass oxalate 44 grs. to 1 oz. of water ; and for warm tones, citric acid 120 grs., ammonium carbonate 88 grs. to 1 oz.

It should be noted that it is important to keep the solutions either absolutely neutral or *slightly* acid. It is best to acidify the potassium oxalate with oxalic or citric acid, and to add a drop or two of sulphuric acid to the ferrous sulphate. This helps to protect it from the oxidising action of the air.

Pyrogallol Developers.—The active agent in these is pyrogallic acid—or, as it is more properly called, pyrogallol, having more resemblance to alcohol than to the acids.

It is one of the benzene substitution compounds, being looked upon as benzene (C_6H_6), having three of its hydrogen atoms substituted by hydroxyl (HO), and thus possesses the formula

$C_6H_3(HO)_3$. It has a very powerful affinity for oxygen, especially in presence of alkalies, becoming converted into a series of dark-brown substances with a powerful staining action, which is its principal inconvenience. It hence has a powerful reducing action, being considerably more energetic in this respect than ferrous oxalate. It was originally prepared by the action of heat on Gallic Acid, which is itself a developer, hence its name.

The pyrogallol developer is capable of considerably more modification and latitude than the ferrous oxalate, being usually made up with other ingredients which modify its action and place great power in the hands of the judicious operator, of controlling his results.

The developer consists of three parts: the reducing agent, consisting of pyrogallol; an alkali which gives it activity, usually termed the "accelerator;" and a "restrainer," which generally consists of bromide of potassium, though bromide of ammonium and citrates of soda and potash are occasionally used for this purpose. The action of ammonia as an accelerator is due partly to the fact that alkaline solutions of pyrogallol absorb oxygen much more rapidly than a neutral solution, as shown by the rapid darkening of an alkaline solution, and partly, according to Captain Abney, to the slight solubility of silver bromide in ammonia. The restraining action of soluble bromide is attributed by the same authority to the fact that it lessens the solubility of silver bromide in the ammonia. Carbonates of sodium and potassium are frequently employed in place of ammonia, but as they have not the same dissolving action upon the silver bromide, there is not the same necessity for a restrainer with them.

The proportions in which these three constituents are employed varies very much with the make of plate—as some will stand much more ammonia than others—the character of the subject, and especially whether it is desirable to keep down over-strong contrasts, or to obtain as much contrast as possible from flat subjects, and the amount of exposure. Under-exposed plates require the use of as much alkali as the plate will stand, accompanied in the case of ammonia with a proportionate increase in the restrainer, whilst over-exposed plates demand very little alkali, and usually, in order to secure greater density and so lessen the thinness which is characteristic of over-exposure, a full proportion of pyro. An average standard developer for a normally exposed plate may be taken to contain 2 grs. pyro, 2 minims ammonia, and 1 gr. potassium bromide in the ounce; but in any case unless the plate is known to be under-exposed, it is well to begin with half the quantity of ammonia, or less, and to add the remainder as required, or not at all. The mode in which the makers of various plates direct the mixing of the developer is most eccentric, and calculated only to confuse the beginner as to the constitution of the mixture with which he is working, and to discourage comparison of developers.

The general tendency, however, is to state the proportion of ammonia as large as possible, so as to give the plates the appearance of greater rapidity; it is desirable, however, only to use this full proportion in extreme cases. The following table, extracted from one compiled by Messrs. Lyonel Clark and E. Ferrero, shows the number of grains to the ounce of each ingredient in the developer:—

Plate.	Pyrogallol.	Ammonium or Potassium Bromide.	Ammonia.	Sodium Sulphite.	Potassium Metabisulphite.
	Grs.	Grs.	Minims.		
Abney and Derby	2	2 to 4	1·60to4		
Britannia	2	2	4		
Edwards' XL	2·1	·5	2		
Fry's Kingston Special ...	2	·71	2		
Ilford	1·85	2·5	4·5		
Mawson and Swan's	1·5	·75	3·75	...	1·5
Paget's Prize	1·8	·45	2·5	7·3	
Thomas' Pall Mall	1·08	1·08	2·4	4·3	
Wratten and Wainwright's ...	3	·33	2·5		

The average of these is, as *nearly as possible*, 2 grs. pyro, 1¼ gr. bromide, and 3 minims of ammonia. The only scientific method of making up solutions and readily securing any desired variation of composition, is to make 10 per cent. solutions, which is easily done as follows: For the pyro take 1 oz. (437½ grs.), and dissolve in 9 (not 10) fluid ounces of water; ammonia, dilute 1 fluid ounce with 9 ozs. water, and for the potassium or ammonium bromide, 1 oz. in 9 ozs. water; then, to make up, say the first on the list, we have only to take 20 minims of No. 1, 20 to 40 minims of No. 2, and 16 to 40 minims No. 3, and make up to 1 oz. with water. In many developers there is an addition of sulphite of soda, or occasionally metabisulphite of potash, which is of undoubted advantage, as, in the first place, it prevents staining of the plate, and, in the second place, if added to the pyro solution in sufficient quantity, it protects it, owing to its own affinity for oxygen from the action of the air. Its introduction is due to Mr. Berkeley, whose sulpho-pyrogallol may be recommended as a convenient and effective 10 per cent. solution; or it may be prepared by dissolving one part in four of warm water, and, when cool, rendering just faintly acid with citric acid, and using 9 ozs. of this solution instead of water, in which to dissolve the 1 oz. of pyro. It is sometimes directed to add a definite amount of citric acid, but this is objectionable, because the alkalinity of various samples of sulphite of soda varies. It is better still to acidify with sulphurous acid, when obtainable, as citrate of soda acts as a restrainer. Other modes of preserving the pyro in solution are with metabisulphite of potash, which does not differ much in properties from sodium sulphite, with citric acid pure and simple, with nitric acid, and with glycerine and alcohol; but none of these are superior to sulphite of soda.

Many workers prefer the carbonates of soda and potash to ammonia as an alkali, and perhaps they are more manageable, though it is difficult, if not impossible, to surpass ammonia and bromide potassium when judiciously used. The Eastman Company recommend for paper negatives: 4 to 5 grs. pyro, 19 grs. sodium carbonate, and 27 grs. sodium sulphite in the ounce; the Beernaert plate developer is 4·78 grs. pyro, 16 grs. sodium carbonate, and 32 grs. sulphite; and Thomas' potash developer is 2·25 grs. pyro, 9·37 potassium carbonate, and 6·75 sodium sulphite; so that one may say, speaking roughly, that the average amount of sodium or potassium carbonate is four times the pyro. There is not much difference between potassium and sodium carbonates. Potassium is said to give detail, and sodium density.

The best all-round developer with which the writer is acquainted, and which in some respects works better than the ammonia developer, is the standard developer of the New York Amateur Society. It consists of (A) potassium carbonate 3 ozs., sodium carbonate 3 ozs., potassium ferrocyanide 3 ozs., water 32 ozs. (B) Sulphite of soda 3 ozs., water 32 ozs. For use, take 1¾ ozs. of B, add 4 grs. dry pyro and 2 drms. A, or, what comes to same thing, for 2 ozs. use 40 minims sulpho-pyrogallol, 2 drms. A, and make up with water. It contains 2 grs. pyro, 5 grs. sodium carbonate, 5 grs. potassium carbonate, and 5 grs. potassium ferrocyanide, along with about 36 grs. sodium sulphite in the ounce of developer. The potassium ferrocyanide appears to act as a restrainer, and has a remarkable effect upon the colour of the negative.

Quinol Developers.—The latest aspirant for favour amongst developers is quinol, or hydroquinone, the former name being, perhaps, preferable. It is another benzene substitution compound, thus having a close relationship to pyrogallol, its composition being $C_6H_4\ (HO)_2$. It was originally obtained from cinchona bark, and is thus associated with quinine, hence its name, but is now manufactured by oxidising aniline with sulphuric acid and potassium bichromate, and afterwards passing sulphurous acid through. It forms crystals, which are much less soluble in water than pyrogallol. Its reducing action is similar to that of pyrogallol, but there is less necessity for a restrainer, and it works best either with potassium or sodium carbonate, or caustic soda. With the former it is less active than pyro, but with the latter it seems quite as rapid. Its great merit is the length of time during which its action can be carried on without staining the plate, and its freedom from fog, permitting the production of great density with clear shadows. Hence it is especially suited for transparencies and lantern slides. Various formulæ are given for its use, varying from 1 gr. to the ounce up to 4 grs., combined with 40 to 50 grs. carbonate soda, or 4 grs. caustic soda.

Comparing two well-known examples by means of a table, we have as follows:—

Name.	Quinol.	Sodium Carbonate.	Sodium Hydrate.	Sodium Sulphite.	Citric Acid.	Bromide Potassium.
	Grs.	Grs.	Grs.	Grs.	Grs.	Gr.
Balagny's ...	$1\frac{1}{2}$	44	...	34	...	$\frac{1}{4}$ to $\frac{1}{2}$
Thomas's ...	4	...	4	22	$1\frac{1}{2}$	$\frac{3}{4}$

The best proportions for this developer can scarcely yet be considered settled, but both the above work well.

With regard to the general principles of development, they have been already indicated, but it may be well to lay down a few special rules.

In dealing with a fully exposed negative it will be best to use at first only a part of the accelerator, adding the remainder to secure detail in the shadows after the high lights are well out. If the plate is known or believed to be under-exposed, it may be soaked at first in the full amount of accelerator and restrainer, afterwards adding the pyro. If the plate, on the other hand, is likely to be over-exposed, exactly the contrary course should be followed, soaking the plate first in the pyro with water, and even increasing the amount of pyro, afterwards adding, slowly and with caution, the accelerator well restrained. If the subject is one with strong contrast, lessen the pyro, which always tends to produce density, and increase the accelerator, so as to hasten the development as much as possible. In such a case, half the pyro and double the ammonia will often be found an improvement. On the other hand, if the subject is flat and likely to produce a thin negative, increase the pyro, and add the accelerator, well restrained, as carefully as possible. The golden rule for development may be stated thus: "Full exposure, followed by slow and tentative development." The same rules, *mutatis mutandis*, may be followed with quinol. Ferrous oxalate, as we have seen, is not susceptible of much modification.

There have been other developers proposed, such as Pyrocatechine, a congener of quinol; Hydroxylamine, which also contains HO, its formula being NH_2OH; but neither of these has as yet met with much favour, and they scarcely need be discussed.

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